

THE RISK OF COMMUNITY-DWELLING OLDER ADULTS BECOMING
DISABLED: APPLICATION OF COX HAZARD MODEL WITH AGE AS TIME
UNIT

Yeong Hun Yeo

A dissertation submitted to the faculty of the University of North Carolina at Chapel Hill
in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the
School of Social Work.

Chapel Hill
2011

Approved by:

Kathleen A. Rounds, PhD

Peggye Dilworth-Anderson, PhD

Dean F. Duncan III, PhD

Shenyang Guo, PhD

Susan L. Parish, PhD

© 2011
Yeong Hun Yeo
ALL RIGHTS RESERVED

ABSTRACT

**YEONG HUN YEO: The Risk of Community-Dwelling Older Adults Becoming Disabled: Application of Cox Hazard Model with Age as Time Unit
(Under the direction of Kathleen A. Rounds)**

As the population of older adults increases, disability among older adults is becoming a critical issue for the disabled themselves and society as a whole. The traditional medical perspective views disability as a direct consequence of injury or disease, and disability among the elderly is regarded as an inevitable result of aging. However, the disablement process model (Verbrugge & Jette, 1994) posits that disability is not only the product of medical conditions, but rather the result of interactions between medical conditions and various intra- and extra-individual factors.

Based on the disablement process model, this dissertation study investigated the black/white disability gap among adults ages 50 and over by investigating risk of disability as defined by difficulty with specific activities of daily living (ADLs) and instrumental activities of daily living (IADLs). Research questions were: 1) Is there a difference between blacks and whites in the risk of disability onset, and does it change with advancing age? 2) If so, to what extent do chronic disease, health behaviors, and socioeconomic status (SES) contribute to that gap? Longitudinal data from a nationally representative sample (N=13,429) were analyzed to track disability onset. Separate analyses were conducted for each of 12 indicators of ADL/IADL disability. To examine the disability gap and how it changes with age, Kaplan-Meier estimates were used to

describe disability onset by obtaining survivor/hazard plots. To examine the mediating roles of disease, health behaviors, and SES, a series of Cox hazard models with age as time unit were utilized.

SES was found to be the largest contributing factor in the black/white disability gap. On average, controlling for SES decreased the gap by 67.7%. When disease, health behaviors, and SES were all controlled for, the gap was narrowed even further. Controlling for these factors also removed the disability crossover phenomenon for most ADL/IADL indicators. This study contributes to the literature by providing a more comprehensive understanding of the disability gap by investigating each indicator of ADL/IADL disability separately, including adults as young as 50 in the sample, and utilizing advanced statistical tools to analyze 11 years of longitudinal data.

ACKNOWLEDGEMENTS

This dissertation would not have been possible without the valuable contribution of my committee members. I feel so fortunate to have wonderful committee members for this dissertation. Most of all, my deepest gratitude is to my advisor and the chair of my dissertation committee, Dr. Kathleen Rounds. Whenever my steps faltered, Dr. Rounds encouraged me to make my steps forward by providing me excellent guidance. I also would like to express my deep appreciation to all my other committee members. Dr. Susan Parish's insightful comments and constructive criticisms helped me enrich my research ideas and learn important issues in the area of disability. The data analysis of this dissertation research could not be completed without Dr. Shenyang Guo's always guidance. Data management skills learned from Dr. Dean Duncan made me possible to utilize efficiently the complex longitudinal structure of the data set used for this dissertation. Dr. Peggye Dilworth-Anderson's expertise on aging helped me recognize crucial aspects of disability among the older adults population, which contributed the implication chapter of this dissertation.

I am also indebted to the all of the members of Institute of Social and Economic Mobility. Their energetic and assiduous research activities awakened and inspired me all the time during the course of my dissertation. Especially, I would like to gratefully and sincerely thank Dr. Michal Grinstein-Weiss for providing me chances to involve many important projects as well as her financial support while I had worked for this dissertation.

I am heartily thankful to Dr. Martha Ozawa. Since I started to work with her, Dr. Ozawa has been my mentor not only by instructing me social work values and the importance of rigorous research but also by offering me warmth advice and various supports.

I would like to acknowledge Mrs. Mary Woytowich at the Center for Community Capital for her continuous support by providing me updated information related to the area of this dissertation, Ms. Jennie Vaughn for her great editorial help, and Dr. Margaret Morse for her kindness advice for me to arrive at this stage and our warmth friendship.

Finally, and most importantly, I would like to thank my wife, two lovely daughters, and my parents for their consistent supports with patience and their faith in me.

TABLE OF CONTENTS

LIST OF TABLES	ix
LIST OF FIGURES	x
Chapter	
I. INTRODUCTION	1
II. DISABILITY AMONG OLDER ADULTS	4
Definition of Disability	4
Significance of Disability among Older Adults	16
III. THE BLACK/WHITE DISABILITY GAP AMONG OLDER ADULTS	23
Research Findings on the Black/White Disability Gap among Older Adults	24
Critique of Research Methods	30
Conceptual Framework of the Study	38
IV. RESEARCH METHODS	42
Data	42
Sample	43
Censoring, Study Window, and Time Origin	45
Measures	47
Data Analysis	52
V. RESULTS	60
Model Diagnostics	60

Univariate and Bivariate Results	61
Bivariate Relationship between Black/White and Disability	65
Mediation Analysis.....	70
Full Model	77
VI. DISCUSSION AND CONCLUSION	86
Summary of Major Findings	87
Strengths and Limitations.....	93
Implications	97
Conclusion.....	108
APPENDICES	110
REFERENCES	123

LIST OF TABLES

Table

1.	Sample Characteristics by All, Black, and White Respondents in the RAND HRS Wave 4	62
2.	Median Survival Ages of Each Disability Indicator.....	64
3.	Disability Survival Ages and Incidence Rates by Black and White Respondents.....	66
4.	Changes in the Black Hazard Ratios of ADL Disability Indicators	72
5.	Changes in the Black Hazard Ratios of IADL Disability Indicators.....	75
6.	Hazard Ratios of ADL Disability Indicators	78
7.	Hazard Ratios of IADL Disability Indicators.....	81

LIST OF FIGURES

Figure

1.	The Disablement Model and the Disablement Process Model.....	15
2.	The Conceptual Framework of the Study.....	39
3.	Survival Curves for Black and White Respondents: Survivor Function by Age	67
4.	Smooth Hazard Curves for Black and White Respondents: Hazard Function by Age.....	69
5.	Model Predicted Survival Curves for Black and White Respondents: Survivor Function by Age	83
6.	Model Predicted Hazard Curves for Black and White Respondents: Hazard Function by Age.....	84

CHAPTER 1

INTRODUCTION

The older population in the U.S. is projected to grow substantially in the coming years because of the aging baby boom generation and the increasing longevity of Americans. According to the most recent Census projections (U.S. Census Bureau, 2010), the number of persons age 65 and older is expected to increase from 40 million in 2010 to 72 million by the year 2030. Given that disability becomes increasingly common as people age, the number of older adults with a disability is also expected to grow to a large extent. Estimates show that 6 million adults age 65 years and older had a disability in 2010; that number will grow to 8.7 million by 2030 and 13.3 million by 2050 (Smith, Rayer, & Smith, 2008). As the number of older adults with a disability increases, disability among older adults is becoming a critical issue for society as well as for the older adults themselves and their relatives, and this issue is attracting considerable public attention.

Disability among older adults is an important concern because it is associated with various negative socioeconomic and health outcomes, such as lower financial resources, an increased need for affordable housing, greater barriers to social participation, lower life satisfaction, depression, higher mortality, greater family caregiver burdens, and higher spending for health care. Indeed, disability affects every aspect of life for older adults, their families, and society as well.

With the more rapid growth in the population of older black adults compared to that of older white adults, the older adult population in the U.S. has become more racially diverse.

According to U.S. Census projections (U.S. Census Bureau, 2010), the proportion of white Americans age 50 and older is expected to decrease from 84% in 2010 to 75% by 2050, whereas the proportion of black Americans age 50 and older will increase from 10% to 13% during that same period. With this increase in the proportion of blacks in the older adult population, the disability gap between black and white adults in old age appears to be an important social phenomenon.

Research on the black/white disability gap among older adults in the U.S. has grown since Verbrugge and Jette (1994) developed the disablement process model that provided an important and thoughtful theoretical guideline for studying disability in old age. The two main trends of studies on the black/white disability gap among older adults in the U.S. have been 1) research focusing on the changes in the disability gap brought about by aging, and 2) research focusing on the source of the disability gap.

Some studies (Clark, Maddox, & Steinhauser, 1993; Johnson, 2000) found the disability gap between the two groups decreased at the oldest ages or even reversed (i.e., the disability crossover phenomenon). However, a few other studies (Clark, 1997; Hayward, Crimmins, Miles, & Yang, 2000; Kelley-Moore & Ferraro, 2004) reported the black/white disability gap continued well into the oldest ages, suggesting a persistent disability disparity. Regarding research focused on the source of the black/white disability gap, most previous studies identified socioeconomic status factors (education, income, and wealth) as the leading cause of the black/white disability gap (August & Sorkin, 2010; Kelley-Moore & Ferraro, 2004), and reported that the inclusion of SES as a mediator completely removed this gap. However, a few other studies (Zsembik, Peek, & Peek, 2000) reported that the gap still existed even after controlling for socioeconomic status, which suggests that there are other

important factors (e.g., disease, health behaviors, housing and neighborhood conditions) in addition to SES that contribute to the black/white disability gap among the aging population. The relative contributions of SES, disease, and health behaviors to the black/white disability gap also differ in various studies. These inconsistent results mostly stem from differences in the data (longitudinal or cross-sectional), methods, definition and measurement of disability, and sample representativeness used by researchers. The conflicting results underscore the need for a more comprehensive investigation of the black/white disability gap utilizing a nationally representative sample drawing from a longer period of longitudinal data. Importantly, the black/white gap for each indicator of Activities of Daily Living (ADL) and Instrumental Activities of Daily Living (IADL) disability is still unknown because most previous studies utilized ADLs and IADLs aggregately to measure disability. Further, studies that include adults approaching older age (e.g., ages 50 to 64) are limited because most earlier studies focused exclusively on the elderly (e.g., ages 65 and older) or the oldest old (e.g., ages 80 and older) to investigate the black/white disability gap.

This dissertation study sets the following two aims to improve our understanding of the black/white disability gap among older adults in a more comprehensive way. First, this study estimates the difference in the age-specific risk of disability onset between black and white adults beginning at age 50. Second, this study focuses on the mediating role of chronic diseases, health behaviors, and socioeconomic status in the pathway from race (i.e., non-Hispanic black and non-Hispanic white) to disability. To achieve those goals, this study utilizes longitudinal data from the nationally representative RAND Health and Retirement Survey and investigates disability onset by separating analyzing each of 12 ADL/IADL disability indicators

CHAPTER 2

DISABILITY AMONG OLDER ADULTS

Interpretation of disability differs by scholar, and scholars' differing perspectives on disability lead to fundamentally different ways of conceptualizing and defining it. These differences are important, because an examination of the causes and influencing factors of disability and/or the racial disability gap is significantly affected by the perspective adopted by the researcher. Thus this chapter begins by introducing three fundamentally different approaches to interpret disability: individual-focused, social-focused, and integrated models.

After reviewing disability perspectives in terms of their strengths, limitations, and applicability to this study, this chapter will discuss the prevalence of disability among older adults in the U.S. and its importance. The older population in the U.S. is growing substantially as baby boomers age and their longevity increases. While the prevalence of disability among older Americans has declined slightly since the early 1980s (Freedman, 2006), the number of older persons with disabilities is expected to grow substantially (Congressional Budget Office [CBO], 1999; Waidmann & Liu, 2000). Disability among older adults is an important issue for the disabled themselves and for society as a whole because it is associated with negative socioeconomic and health outcomes.

Definition of Disability

The meaning of disability differs among scholars. Approaches to interpreting disability are usually categorized into individually focused vs. socially focused perspectives. The individual perspective on disability regards disability as an inevitable and necessary

consequence of a disease or illness. In contrast, the social perspective on disability regards disability as a consequence of physical, attitudinal, social, and environmental barriers encountered by persons having physical or mental impairments. Some approaches to defining disability integrate the individual and the social perspectives. These integrated approaches stress both individuals' functional abilities and environmental and social context to explain disability (Verbrugge & Jette, 1994).

The choice of perspective is important, because different perspectives on disability lead to fundamentally different ways of conceptualizing and defining disability. When disability is interpreted as an individual's medical condition in favor of the individual perspective, the black/white disability gap is regarded as the result of the individual's fixed characteristics such as disease and impairment. As such, the individual model does not account for any social, environmental, or behavioral factors that might be influencing disability (Oliver, 1996). However, when disability is interpreted using the social perspective, disability is regarded as the result of prejudice, discrimination, and disadvantages imposed on the persons with chronic conditions and impairments (Depoy, 2002; Hahn, 1993; Oliver, 1996). This perspective largely ignores the influence of the individual's physical or mental impairments to explain the black/white disability gap.

The integrated approaches, such as the International Classification of Functioning, Disability and Health (ICF) model and the disablement process model, stress both the individual's functional abilities and social/environmental factors to explain disability (Verbrugge & Jette, 1994). According to these approaches, the black/white disability gap emerges because of the differences in various intra- and extra-individual characteristics among blacks and whites.

This section reviews the individual and social perspectives on disability, as well as the integrated approaches, in terms of their important assumptions, limitations, and applicability to empirical studies that examine influencing factors on the black/white disability gap.

Individual-focused perspective. The individual perspective on disability, also called the medical model, is related to the personal tragedy theory, which explains disability as a tragic personal matter caused by the person's deficit (Oliver, 1996). The individual perspective on disability is also called the old paradigm of disability (Dejong & O'Day, 1998) and the medical-diagnostic approach (Gilson & Depoy, 2002).

This individual perspective regards disability as a personal problem directly caused by disease, accident, or other chronic condition(s). In this view, disability is conceptualized as a direct outcome of pathology (Leclair, Leclair, & Brigham, 2009; Minaire, 1992). The important assumptions of this perspective are: 1) disability is defined primarily as a disease or deficit state and absolutely in medical terms; 2) persons with disabilities are viewed as biologically and psychologically inferior; and 3) medication and individual treatment are the primary focuses of intervention, and medical professionals play a key role in intervention (Barnes & Mercer, 2010; Barnes, Mercer, & Shakespeare, 1999; Shakespeare & Watson, 1997; Smith, 2009; Weiss & Lonnquist, 1997).

In 1965, Nagi expanded the traditional medical model by introducing the Nagi disablement model (Nagi, 1965), also called the functional limitation perspective (Bernell, 2003). Nagi's model first introduced the four stages of the disability pathway: pathology (defects of organ function due to chronic conditions or injury), impairments (loss of a system function), functional limitation (limitations in physical or mental activities due to the

impairment), and disability (inability to perform physical and social roles required in daily living) (Nagi, 1991). The pathway from pathology to disability is referred to as “disablement.” This model introduced social context as important to the concept of disability. Disability is regarded as a distinctly different stage from functional limitation or impairment. In this model, functional limitation is a functional incapacity itself; however, disability is a functional incapacity that keeps an individual from performing a socially defined role (Freedman, Martin, & Schoeni, 2004).

Independent from the development of the Nagi model, the World Health Organization (WHO) developed the International Classification of Impairments, Disabilities, and Handicaps (ICIDH) model in late 1970s to “provide a classification scheme . . . with the intent to facilitate study of the consequences of disease” (WHO, 1980, p. 35). Like the Nagi model, the ICIDH model distinguished disability from disease or impairment by introducing the following four distinct concepts: disease, impairment, disability, and handicap. The ICIDH model defines disability as “any restriction or lack of ability to perform an activity in the manner or within the range considered normal for a human being” (WHO, 1980, p.143).

Although both the Nagi and ICIDH models expand the traditional individual perspective on disability by including social context in their conceptualization of disability, they still view disability as a direct and inevitable consequence of pathology or impairment. Thus, both models share limitations with the individual perspective on disability—of which there are many. First, disability is seen as a personal responsibility. Consequently, persons with disability are defined as defective, abnormal, and inferior (Abberley, 1987; Oliver, 1996). Second, the individual perspective on disability ignores the role of social and physical environments in making a place for persons with disabilities—in other words, society is not

responsible for accommodating persons with disabilities (Abberley, 1987; Oliver, 1996). Third, the individual perspective privileges medical professionals in intervention strategies by ignoring the roles of persons with disabilities themselves (Abberley, 1987; Taylor, 2005). Finally, the individual perspective does not make any efforts to address the social, economic, and environmental factors that influence the lives of the persons with disabilities (Begum, 1992).

Despite its limitations, the individual perspective still plays a dominant role in disability policy as well as in clinical settings (Taylor, 2005). Because disability has long been regarded as a medical issue rather than a social issue, medical professionals have played a key role in this area. Both the Nagi and ICIDH models, as expansions of the individual perspective, also have been advanced as important frameworks for rehabilitation practice (Barnes et al., 1999; Lutz & Bowers, 2007). However, the individual perspective has major limitations in the examination of the black/white disability gap. This perspective recognizes disability in older adults exclusively as an unavoidable result of detriments of individual medical conditions. Therefore, the source of the black/white disability gap is understood as racial differences in pathology and impairment caused mainly by inherent biological and genetic detriments. This viewpoint has been challenged by most studies on the racial disability gap. Previous studies (e.g., Dunlop, Song, Manheim, Daviglus, & Chang, 2007), consistently reported that while individual medical conditions explain some portions of the racial disability gap, these were not the main causes of the gap.

Social/environmental-focused perspective. In response to the criticism of the individual perspective, the social perspective began to emerge in the late 1960s (Lutz & Bowers, 2007; Oliver, 1996). The social perspective is regarded as the new paradigm of

disability (DeJong & O'Day, 1998) or the constructionist approach (Gilson & Depoy, 2002).

The social perspective has its roots in the tradition of the civil rights movement, social justice, consumerism, and the disability rights movement (DeJong, 1979; Malhotra, 2001). British scholar and activist Michael Oliver first introduced this binary categorization between the individual and the social perspectives of disability, echoing and elaborating upon the distinction between impairments and disability claimed by the Union of the Physically Impaired against Segregation in the United Kingdom (UPIAS) (Oliver, 1983). UPIAS insisted that “disability is something imposed on top of our impairments by the way which we are unnecessarily isolated and excluded from full participation in society” (UPIAS, 1976, p. 14).

This perspective is related to social oppression theory, which argues that the problems faced by persons with disabilities are not the result of physical impairment but rather the result of the existing social and political inequality in society (Abberley, 1987). The social perspective is also called the minority model of disability, because it views persons with disabilities as a minority group within a society controlled by persons without disabilities (Hahn, 1994).

The important assumptions of the social perspective are: 1) disability is not a personal physical or mental condition (Swain, Finkelstein, French, & Oliver, 1993); rather, persons with disabilities are victims of a disabling society—that is, a society controlled by persons without disabilities that excludes persons with disabilities from all aspects of living (Hahn, 1994; Swain, French, & Cameron, 2003); 2) disability results from society's inability to account for the needs and abilities of persons with disabilities (Abberley, 1987; Oliver, 1996; Smith, 2009; Swain et al., 2003), and from society's discrimination and prejudice against

persons with disabilities (Barnes & Mercer, 2009; Hahn, 1993); and 3) the problems of persons with disabilities should be addressed by the removal of attitudinal, physical, and institutional barriers toward people with disabilities, rather than through individual adaptation to society by medical treatment (Abberley, 1987; Barnes, Mercer, & Shakespeare, 2009; DeJong, 1979; Oliver, 1996).

The major limitation of the social perspective is its neglect of the individual's physical or mental impairments, as it sees societal structures as the sole cause of disability and focuses only on environmental barriers and social attitudes (Morris, 1998; Smith, 2009). Therefore, the social perspective provides only a limited and partial explanation of the relation between impairments, disability, and society (Terzi, 2004). Moreover, there are no standard or widespread instruments to measure disability using the social perspective because of difficulties in quantifying social prejudice, discrimination, and environmental barriers against persons with chronic conditions and impairments.

According to the social perspective, the black/white disability gap is explained solely by racial differences in confronting social and environmental barriers against persons with illness and impairments. An examination of the black/white disability gap using the social perspective is incomplete and limited because it does not include the influence of individual characteristics such as medical conditions and health behaviors.

Integrated models. Based on critiques and appreciation of both the individual and the social perspectives, several scholars have made efforts to develop an integrated model of disability with emphasis on the interaction between individual and environment (Lutz & Bowers, 2007) and on coordination between medical professionals and persons with disabilities in parallel roles (Pffefier, 2001).

These integrated approaches of disability are supported by theories of aging. First, the ecological model of aging by Lawton and Nahemow (1973) posits that health among the elderly is determined by the interplay among biological, behavioral, social environmental, and physical environmental factors. The ecological model also posits that satisfaction or personal well-being can be achieved when environmental demands and individual capacities are balanced (Putnam, 2002). Satiriano (2005) points to the disablement process model by Verbrugge and Jette as an important example of the ecological model of aging.

Second, the life course theory of aging (Elder, 1999) emphasizes the importance of three key demographic factors—age, period, and cohort—to explain the onset of disease or disability in the lives of individuals. According to Guo (2010, p. 9), age refers to physiological change related to the aging process. For example, impairments and frailty increase with advancing age. Period denotes the time at which an outcome occurred, and *period effect* refers to outcomes that are common to the entire population that lived during a particular time period. A cohort is a group that shares a common characteristic, and a *cohort effect* is the result of an event that affects only a particular group. In this view, differences in health outcomes or disabilities among older adults can be explained by age, cohort, and period effects together with cumulative risk factors and personal biological and behavioral factors (Halfon & Hochstein, 2002). In other words, each older adult experiences different a health or disability trajectory determined by interactions of biological characteristics, accumulation of risk factors, and environmental and historical contexts (Baker, Eriksson, Forsen, & Osmond, 2002; Young, 1998).

Third, the model of successful aging (Rowe & Kahn, 1987, 1997), an emerging paradigm of gerontology, also supports an integrated model of disability. Typically, aging is

viewed negatively with the belief that decrements of physical and mental functioning in old age are normal (Ashauer, 2010). In gerontology, this negative view is mainly influenced by the biomedical model, which focuses on physical processes affecting illness through biological factors such as genetics while disregarding influences of psychological, socioeconomic, and environmental factors (Victor, 2005). This negative view, called the decline and loss paradigm (Minkler & Fadem, 2007), results in ageism that reflects a prejudice and discrimination in society against older adults. According to this viewpoint, aging is defined as a process toward gradual deterioration of physiological function with age (Partridge & Mangel, 1999). The increase in vulnerability of older adults is viewed as inevitable, intrinsic, and irreversible (Comfort, 1964). Thus, aging itself is the most powerful determinant of illness and disability. In contrast to this negative view of aging, the successful aging paradigm (Rowe & Kahn, 1987, 1997) recognizes the important role of extra-individual factors to explain disability among older persons. In the successful aging paradigm, the aging process is described with categories: “usual aging” (also called typical aging), focusing on extrinsic factors that exacerbate the effects of aging, and “successful aging” highlighting extrinsic factors that neutralize these effects (Minkler, 1990). This paradigm explains that health, illness, and disability associated with the aging process are the result of various extrinsic factors such as lifestyle, health behaviors, and psychosocial factors (Minkler & Fadem, 2007; Rowe & Kahn, 1987, 1997).

Two important integrated models of disability are the International Classification of Functioning, Disability and Health (ICF) model developed by the World Health Organization (WHO) in 2001, and the disablement process model developed by Verbrugge and Jette in 1994.

The ICF model is a modification of its earlier framework, the ICIDH model. The ICF model was originally developed to provide a standard framework for the description of health-related states and to be used as a diagnostic guide by clinicians (Stamm & Machold, 2007; WHO, 2002). The ICF model regards disability as a multi-dimensional concept comprised of the following three aspects: body functions and structures, activity limitations, and participation restrictions. Body functions and structures can be seen as similar to impairments. Activity limitations imply difficulties in performing tasks or actions. Participation restrictions are difficulties in involvement in life situations (WHO, 2001). The meaning of disability in this model includes all aspects of impairments, activity, and social participation. The model also introduces personal and environmental factors that can influence body functions and structures, activity, and participation (WHO, 2001). Therefore, the ICF model is viewed as a holistic perspective of disability based on the biopsychosocial model (Stamm & Machold, 2007) and on the ecological model (Smart, 2007). Further, by positioning disability as part of the continuum of health status, the ICF model views disability as a universal human experience (WHO, 2008a).

The ICF model has been often used as a guideline for empirical studies focusing on social participation among persons with disabilities because the ICF model considers participation to be an important aspect of disability (e.g., Noreau et al., 2004; Perenboom & Chorus, 2003; Takeyachi et al., 2003). However, applying the ICF model to the study of the black/white disability gap has limitations. First, the model was originally developed for use in clinical settings as a classification tool or terminology system. Second, the model has not been applied and tested extensively with older adults with disabilities. Third, national data

including the ICF measure¹ is quite limited in the United States. Fourth, in the ICF model, measures of disability are ambiguous because disability is regarded as a comprehensive condition having multi-dimensional aspects, including functional impairments, activity limitations, and participation restrictions.

The disablement process model by Verbrugge and Jette (1994) extensively revised the earlier disablement model by Nagi (1965). Figure 1 provides a comparison between the two models. Nagi's disablement model has been criticized on two points. First, the Nagi model views disablement as a static or unidirectional process, rather than a dynamic process (Marge, 1988). Second, and more importantly, most experts now believe that disablement can be influenced by various personal, social, and environmental factors, and that the process of disablement can be accelerated or slowed by various individual and environmental characteristics. However, the Nagi model stresses the individual's chronic condition or impairments as the only cause of disability (Verbrugge & Jette, 1994).

In response to these criticisms, Verbrugge and Jette (1994) introduced the disablement process model by expanding Nagi's disablement model to include comprehensive intervening factors in the main pathway of disablement (pathology to disability). Verbrugge and Jette categorize these intervening factors as risk factors, intra-individual factors, and extra-individual factors. Risk factors are defined as predisposing characteristics that exist before the onset of disability, such as socio-demographic background. Intra-individual factors represent characteristics or behaviors within a person that occur after the onset of a disabling condition; examples include lifestyle and behavior changes and psychological attributes. Extra-individual factors are factors outside the person,

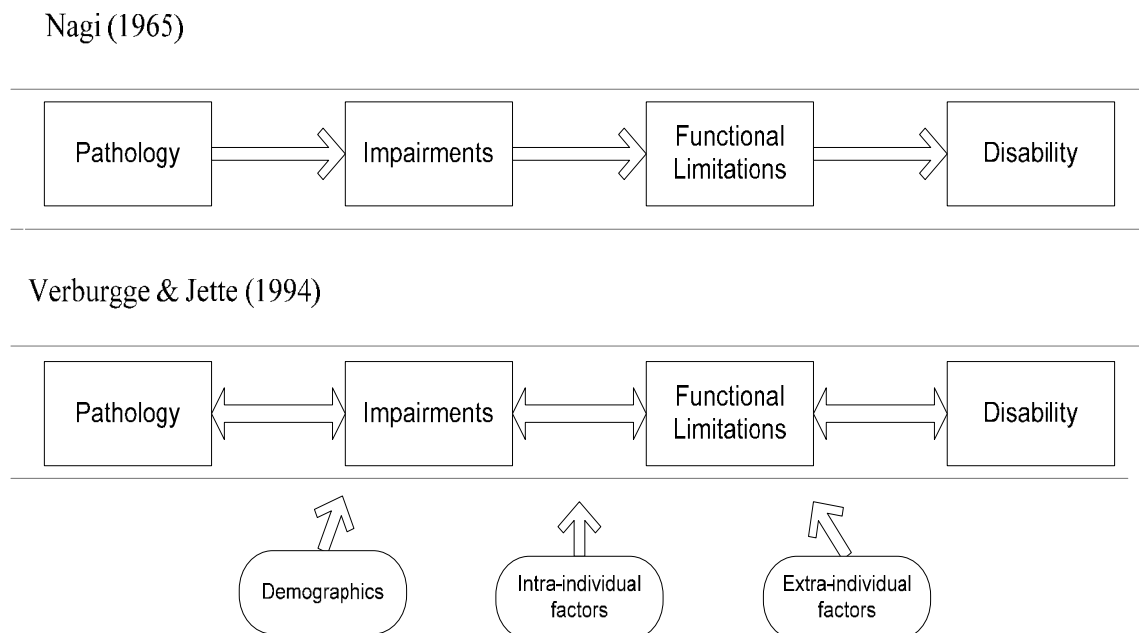
¹ The ICF model provides structured and detailed classification codes including 34 first level codes (8 body functions, 8 body structures, 9 activities, and 9 participation codes), and 1,424 sub-codes by specification of each type of the first level codes (see WHO, 2008b).

such as medical and rehabilitation services, personal assistance, access to buildings, discrimination, prejudice, access to care, and access to public transportation. The main pathway of disablement is the same as that in Nagi's disablement model: pathology, impairments, functional limitations, and disability (Verbrugge & Jette, 1994).

By combining the main disablement pathway (pathology → impairments → functional limitations → disability) with influencing factors (risk, intra-individual, extra-individual) in their model, Verbrugge and Jette's disablement process model makes a clear distinction between 1) the effect of chronic and acute conditions on disability, through the disablement pathway, and 2) influencing factors that interplay between medical conditions and disability (Jette, Hamilton, Liang, & Whiteneck, 1997).

Figure 1

The Disablement Model and the Disablement Process Model



In the disablement process model, disability is regarded not as a personal characteristic, but as a gap between personal capability and the sociocultural environment. In other words, disability refers to the expression of functional limitation within the social context. Disease or impairments do not necessarily lead to disability in this model, because influencing factors affect each person differently (Verbrugge & Jette, 1994). That is, disability is defined as the inability to perform specific social roles in everyday life (such as bathing, dressing, using a phone) *because of* these functional limitations. The transition from pathology or impairment to disability depends on the interactions between the individual's capacity, risk factors, intra- and extra-individual factors, and demands of their social and physical environments (Satariano, 2004; Verbrugge & Jette, 1994).

The disablement process model provides the most complete and clear definition of the intervening factors of disablement. The model also implies that disablement is differently experienced by each individual, with intervening factors (risk, intra-individual, and extra-individual) playing a key role to explain this difference. Therefore, the disablement process model is the most appropriate model for this study of influencing factors on the black/white disability gap among older adults. As Satariano (2004) emphasized, the model has been used as an important guide for researchers investigating disability among older persons.

Significance of Disability among Older Adults

Since disability is defined and measured in different ways, estimates of the prevalence of older adults with disabilities vary across studies. Manton, Gu, and Lamb (2006), who defined disability as any difficulties in ADLs or IADLs,² estimated that 19% of

² The most widely used instruments to measure disability are activities of daily living (ADLs) and instrumental activities of daily living (IADLs), because of their widespread use in many U.S. national surveys such as the Survey of Income and Program Participation (SIPP), the Health and Retirement Survey (HRS), and the National

U.S. adults age 60 and older had a disability, as did 49.7% of adults age 80 and older, according to data gathered by the National Long Term Care Survey (NLTCS) in 2004-2005.

The U.S. Census Bureau has adopted a broader definition of disability, defining disabled persons as persons who have any difficulties in ADLs or IADLs, functional limitations, a mental or emotional condition, work limitations because of impairments, or who use assistive tools. Using this definition, the Census estimated that in 2005, the prevalence of disability among the entire U.S. population was 18.7%; among adults ages 55 and older, it was much higher, 41.8%.³ The prevalence of disability among black adults age 55 and older was 51.0%, compared to 40.5% among white adults in that age group.

While the prevalence of disability among older Americans has declined slightly since the early 1980s (Freedman, 2006), the number of older persons with disabilities is expected to grow substantially in coming years (Congressional Budget Office [CBO], 1999; Waidmann & Liu, 2000) because of the increase in the elderly population due to the the aging of the baby boom generation and the increasing longevity of Americans. For example, Smith and colleagues (2008) estimate that the number of adults ages 65 and older with a disability will grow from 6 million in 2010 to 8.7 million by the year 2030, and 13.3 million by 2050.⁴

The expected gradual increase in the number of older adults with a disability is an important issue for aging adults because disability affects every aspect of life for older adults

Health Interview Survey (NHIS). In many studies that estimate the prevalence of persons with disability, “persons with disabilities” is defined as persons with any difficulties in ADLs or IADLs.

³ The estimation is based on this author’s calculation using Tables D-1, D-2, and D-3 in the Census report *Americans with Disabilities: 2005* (U.S. Census Bureau, 2008).

⁴ The estimates by Smith and colleagues (2008) are based on three mobility related ADLs, whether the respondent has a condition lasting six months or more that makes it difficult to dress, bathe, or get around inside the home.

and their families. The negative relationship between disability among older adults and various individual and social outcomes has been well-established in numerous studies.

First, there is a strong relationship between disability and lower financial resources (i.e., higher poverty rates, lower income, and fewer assets) among older adults, and this relationship appears to be strengthening (Schoeni, Martin, Andreski, & Freedman, 2005). Studies have consistently reported that disability among older adults was highly associated with lower economic backgrounds, such as higher risk of being poor, lower income, and fewer assets (Costa-Font, 2008; Kaye, Kang, & LaPlante, 2004; Matthews, Smith, Hancock, Jagger, & Spiers, 2005; Ozawa & Yeo, 2007, 2008). For example, Ozawa and Yeo (2007) found the total net worth of elderly persons with a disability was only about half of the net worth of the elderly without a disability. In spite of more limited financial resources, the elderly with disabilities spend more money on medical care and medical aids than the elderly without disabilities (Trupin, Rice, & Max, 1995). Because of lower financial resources, higher medical spending, and a higher cost of living, elderly persons with a disability face severe financial pressure.

Second, there is an enormous gap between the need for and supply of affordable and accessible housing among older adults with a disability. This gap is continuously growing due to the increasing number of older adults with disabilities (Smith et al., 2008). Housing environment is a main topic of environmental gerontology (Iwarsson, 2005) because it is critical to the well-being of the elderly and greatly impacts independent living among older adults. Kochera (2002) found that more than 90% of the elderly preferred to remain in their current homes for as long as possible (Kochera, 2002). The United States' aging policy is also placing an increased emphasis on helping older adults stay in their homes and

communities as long as possible (Reynolds & Silverstein, 2003; Smith et al., 2008). However, most housing units in the United States are not accessible to older adults with a disability. Although more than 30% of adults ages 65 or older had difficulty with walking or using stairs, less than 10% of housing units in the United States are accessible to individuals with mobility problems (Steinfeld, Levine, & Shea, 1998). Most housing units for the elderly with disabilities have not been modified with accessibility features (Smith et al., 2008). Older adults with a disability who do not live in adequately accessible housing are often forced to move into institutions such as nursing homes, which imposes high financial costs on both individuals and society (Smith et al., 2008).

Third, disability creates barriers to social participation, life satisfaction, and quality of life. A major aim of disability policies and programs in the U.S. is to encourage persons with a disability to contribute to society by maximizing their abilities (Freedman et al., 2004). This aim can be achieved when there are no barriers to social activities, productive activities, and social interaction. However, studies have consistently reported that older adults with a disability had significantly fewer social relationships and limited social participation compared to older adults without a disability (Avlund, Lund, Holstein, & Due, 2004; Cerhan & Wallace, 1993; Kuo, Raji, Peek, & Goodwin, 2004; Mendes de Leon, Gold, Glass, Kaplan, & George, 2001). Further, older adults with a disability have lower levels of life satisfaction (Husani & Moore, 1990; Kemp & Krause, 1999). These lower levels of social participation and life satisfaction result in a poorer quality of life among older adults with a disability (Noreau et al., 2004).

Fourth, studies have frequently reported that depression is highly associated with older adults with a disability (Alexopoulos et al., 1996; Bruce & Hoff, 1994; Bruce, Seeman,

Merrill, & Blazer, 1994; Bruce et al., 2002; Cole & Dendukuri, 2003; Ormel, Rijdsdijk, Sullivan, van Sonderen, & Kempen, 2002; Penninx, Leveille, Ferrucci, van Eijk, & Guralnik, 1999). For example, Cole and Dendukuri (2003) conducted a meta-analysis based on 22 empirical studies published between 1967 and 2001, and they found that disability was one of the major risk factors for depression among older adults. Higher rates of depression among older adults with a disability are associated with lower participation in community activities and a lower quality of life (Kemp, 1999), and depression is also a critical risk factor in mortality (Schulz et al., 2000; Yaffe, Edwards, Covinsky, Lui, & Eng, 2003).

Fifth, disability among older adults influences health care spending, which places a large burden on the disabled themselves as well as their families and the government funding that supports health care services. Studies have reported that older adults with a disability spend more on health care than older adults without a disability. For example, Trupin and associates (1995) found that the cost of medical care for older adults with a disability was three times higher than for older adults without disabilities. More specifically, Chernew, Goldman, Pan, and Shang (2005) reported that the cost of medical care for the elderly without a disability was half as much as the amount spent on the elderly with a mild disability (difficulty with 1 or 2 ADLs) and only a fifth as much of the amount spent on the elderly with a severe disability (difficulty with more than 5 ADLs). Interestingly, Jette (1996) highlighted that the prevalence of disability among older adults was more directly related to medical and social service utilization than disease itself. Estimations of future disability prevalence among older adults have been used as a key index to predict future Medicare expenditures because of the direct influence of disability among older adults on health care

expenditures (Bhattacharya et al., 2004; RAND, 2005) and Medicaid expenditures (Stearns, Norton, & Yang, 2007).

Sixth, family caregivers play a crucial role in supporting older adults with a disability. According to the Family Caregiving Alliance (2006), more than 80% of older adults with ADL disabilities live in the community thanks to informal assistance primarily from their families. The major reason for this heavy reliance on informal family care is the expense of long-term care and paid services (Johnson, 2007). Family caregivers provide various types of support, such as help with activities inside the home (i.e., bathing, eating, preparing meals, monitoring medications) and outside the home (i.e., transportation, shopping), contacting service agencies (i.e., physicians, local community aging centers), and emotional support (Schmieding, 2006). In the United States, the number of family caregivers for the frail elderly is estimated at 29 million (Arno, 2006). This crucial role of the family caregiver to support the frail elderly inevitably places various burdens on the caregiver. Studies have reported that caregivers encounter a variety of poor health outcomes such as headaches, exhaustion, sleep disorders, pain, depression, and anxiety (Beach et al., 2005; Braithwaite, 2000; Mittelman, 2002; Ory, Hoffman, Yee, Tennstedt, & Schulz, 1999; Polen & Green, 2001), and increased risk of mortality (Christakis & Allison, 2006). Also, caregivers lack time for themselves, social activities, and exercise (Moen, Erickson, & Dempster-McClain, 2000).

Financial pressure is another significant burden for family caregivers of frail older adults. Financial pressure includes both the direct costs of medical services, hiring helpers, and purchasing assistive equipment, and the indirect costs of lost income because of caregiving responsibilities (Hooyman & Kiyak, 2008). In 2006, the average hourly rate for a

home helper was about \$20, resulting in an annual cost of about \$14,000 for 60 hours of home help services per month (Metlife Mature Market Institute, 2006). Further, caring for frail older adults is significantly associated with reduced work hours, leading to part-time jobs or unemployment, and higher risk of being in poverty (Ettner, 1996; National Alliance for Caregiving and AARP, 2004; Rubin, 2002).

After investigating the prevalence of older adults with a disability, this section reviewed the importance of disability among older adults in terms of financial strain, need for adequate housing, social participation and quality of life, depression, increasing health care expenditures, and family caregiver burdens. It is clear that disability affects every aspect of life for older adults, their families, and society as well. Indeed, delaying a disability among older adults is just as important as prolonging life (Guralnik, Fried, & Salive, 1996).

CHAPTER 3

THE BLACK/WHITE DISABILITY GAP AMONG OLDER ADULTS

With the more rapid growth of the population of minority older adults compared to that of the white older adults, the overall older adult population in the U.S. has become more racially diverse. For example, the proportion of white Americans ages 50 and older is expected to decrease from 84% in 2010 to 72% by 2050, whereas the proportion of black Americans will increase from 10% to 13% during that same period (U.S. Census Bureau, 2010). This increase in the proportion of older black adults raises the subject of health disparities (i.e., mortality, diseases, and impairments, as well as disability) between older white and black adults as a crucial topic among gerontologists, especially given that health-related problems (i.e., higher mortality rate, lower longevity, and higher prevalence of disability) are more prevalent among older black adults.

Interest in the disability gap between black and white older adults has grown since the introduction of the disablement process model developed by gerontologists Verbrugge and Jette in 1994. Previous studies on the black/white disability gap primarily examined one or both of two topics: 1) whether the disability gap continues as older persons approach the end of life, and 2) the source of this gap. This chapter reviews findings from previous studies of the black/white disability gap and then critiques their research methodology. The chapter also presents a conceptual framework developed for this dissertation research. Research questions, hypotheses, and the significance of this dissertation study are also presented.

Research Findings on the Black/White Disability Gap among Older Adults

Among older adults in the U.S., the prevalence of disability is much higher among blacks than whites. According to the Census Bureau (2008), the prevalence of disability in 2005 among blacks ages 55 and older was 51.0% compared to 40.5% among whites in the same age group. One theory that is frequently cited to explain the higher proportion of disability among older black adults compared to older white adults is the cumulative disadvantage theory (Merton, 1968).

This theory explains how earlier success could increase the likelihood of future success without continuing efforts, and also emphasizes the importance of early advantage or disadvantage to different outcomes in later life such as health, income, and work status (Ferraro & Kelley-Moore, 2003). In the literature on racial health disparities, the cumulative disadvantage theory has been applied to underscore accumulated exposure to stressors across the life course among racial minorities (Taylor, 2008). Specifically for the black/white disability gap, the theory posits that older black persons are more likely to be disabled due to disadvantages associated with their minority status, such as discrimination and a lack of socioeconomic resources over the life course (Maddox & Clark, 1992).

The double jeopardy hypothesis (Dowd & Bengtson, 1978) also attracted the attention of gerontology researchers examining the racial health gap among older adults. The hypothesis posits that greater health inequalities experienced by racial minorities worsen with advancing age (Ferraro & Farmer, 1996). According to this hypothesis, the black/white disability gap increases in older age because of the double disadvantage of age and minority status.

Despite the significant difference in the prevalence of disability between black and

white older adults, this topic had not received much attention until the 1990s. Since the development of the Verbrugge and Jette (1994) disablement process model that provided a fundamental frame to investigate disability among older adults, research focusing on the black/white disability gap among older adults in the U.S. has grown to test the double jeopardy hypothesis by asking whether the black/white disability gap widens or narrows with advancing age, and to identify the influencing factors of this gap.

With a few exceptions (Andresen & Brownson, 2000), most studies have reported that older black adults were more likely to be disabled than older white adults. While some studies found that this disability gap continued well into the oldest ages, suggesting a persistent disparity between whites and blacks (Clark, 1997; Hayward et al., 2000; Kelley-Moore & Ferraro, 2004; Mendes de Leon, Barnes, Bienias, Skarupski, & Evans, 2005), many others found that the racial disability gap among older adults diminished with advancing age. Further, some studies found that the disability gap converged among the oldest adults (Clark & Maddox, 1992; Clark et al., 1993; Gibson, 1991; Johnson, 2000; Mendes de Leon, Seeman, Baker, Richardson, & Tinetti, 1996; Mutchler & Burr, 1991). For example, Clark and colleagues (1993) found that while blacks ages 70 to 84 were more likely to have ADL decline compared to whites in the same age range, blacks ages 85 and over were *less* likely to experience ADL decline than whites in that age range. Johnson (2000) also found the black/white ADL disability gap converged at age 86. This convergence of the disability gap between black and white older adults is called the crossover phenomenon of disability⁵ (Kelley-Moore & Ferraro, 2004).

⁵ The racial crossover of mortality in old age has been a popular topic in the field of demography and gerontology since the late 1970s (Manton, Poss, & Wing, 1979; Nam, Weatherby, & Ockay, 1978; Wing, Manton, Stallard, Hames, & Tryoler, 1985). However, the racial crossover of disability in old age did not attract research attention until the 1990s.

Ozawa and Yeo (2008) offered several possible explanations for this phenomenon: 1) in the later stages of life, black survivors are physically and mentally stronger compared to white survivors (mortality selection or selective survival); 2) older black persons have a greater ability to cope with difficulties in old age because they had significant experiences with hardship earlier in their lives; 3) older black persons have stronger social networks than older white persons, which could help them deal with frail health conditions in old age; and 4) race or ethnicity is not necessarily directly related to developing a disability; rather, individual strengths and status (e.g., SES, physical health and disease, health behaviors) were better predictors of developing a disability in later life. That is, the racial disability gap is mediated by other factors.

Among the many possible explanations for the racial disability gap, many studies have focused on investigating important mediating factors in the relationship between race and disability. Among various possible mediators, SES has been highlighted in most studies as the main factor explaining the black/white disability gap among older adults. For example, August and Sorkin (2010) reported that the black/white disability gap among older adults was reduced (for adults ages 65 to 74) or eliminated (for adults ages 55 to 64 and ages 75 and older) when demographics and SES were controlled. Investigating 4,162 adults ages 65 and older in five counties in North Carolina, Kelley-Moore and Ferraro (2004) found that the disability gap for this age group became non-significant when SES, social integration, and other health indicators were controlled. Using a nationally representative sample from the RAND HRS, Ozawa and Yeo (2008) found that when SES and demographic variables were taken into account, the odds of being ADL or IADL disabled were not significantly different for the black elderly vs. the white elderly. Many other studies have also reported the

significant mediating role of SES in the relationship between race and disability among older adults (August & Sorkin, 2010; Fuller-Thompson, Naru-Jeter, Minkler, & Guralnik, 2009; Guralnik, Land, Blazer, Fillenbaum, & Branch, 1993; Kelley-Moore & Ferraro, 2004; Kington & Smith, 1997; Song et al., 2007; Mendes de Leon et al., 2005; Schoeni et al., 2005; Taylor, 2008). These studies found that while a racial disparity existed, it was largely due to differences in SES between older black and older white adults.

However, findings regarding the extent to which SES contributes to the racial disability gap have varied. For example, Guralnik and colleagues (1993) and Dunlop and colleagues (2007) found that the black/white disability gap in older adults was eliminated after controlling for SES. Fuller-Thompson and colleagues (2009) also found the odds ratios for disability in older black men vs. older white men became no longer significant after controlling for income and education, which explained 90% of the black/white ADL disability gap. Kington and Smith (1997) reported that SES explained almost all the racial disability gap, but accounted for only moderate amounts of the gap between races in disease prevalence. Mendes de Leon and colleagues (2005) and Liang, Xu, Bennett, Ye, and Quinones (2009) found that the black/white disability gap among older adults was still present even when controlling for SES, although SES substantially reduced this gap. Clark and colleagues (1993) also found that SES did not fully account for the racial disability gap. These findings suggest that there are other important factors in addition to SES that contribute to the black/white disability gap among the aging population.

While most previous studies on the black/white disability gap in older adults focused on SES as a leading mediating factor, a few studies also investigated the mediating role of health behaviors (e.g., physical activity, smoking, drinking, BMI). For example, Popa,

Reynolds, and Small (2007) found that health behaviors narrowed the black/white IADL disability gap but not the ADL gap. They also reported that none of the health behavior variables significantly affected ADL or IADL disability trajectories among black respondents after controlling for both SES and health status together. Dunlop and colleagues (2007) found the hazard ratio for developing an ADL disability among black adults ages 65 and older decreased from 1.57 to 1.28 after including health behavior variables when using Cox regression to explore the racial gap in ADL disability onset. A study by Bolen, Rhodes, Powell-Griner, Bland, and Holtzman (2000) found that poorer health behaviors and lifestyles (e.g., smoking, lower physical exercise, and heavy alcohol consumption) among the minority population led to a greater risk of morbidity and mortality, as well as disability. Examining black and white older adults separately, Clark (1996) found that increased “walking frequency” decreased the risk of becoming disabled for both groups.

Chronic disease is another mediator that has been frequently investigated by researchers (Dunlop et al., 2007; Kelley-Moore & Ferraro, 2004; Moody-Ayers, Mehta, Lindquist, Sands, & Covinsky, 2005; Song et al., 2007; Taylor, 2008; Zsembik et al., 2000). According to the disablement models of Nagi (1965) and Verbrugge and Jette (1994), chronic disease is the main source of disability. Nagi’s model posits a direct and linear causal relationship from disease to disability. According to the individual and medical perspective of disability posited in Nagi’s model, the root of the racial disability gap is biological or genetic factors leading to a greater risk of chronic disease among the minority population. Thus, chronic disease is the most powerful source of the racial disability gap. However, Verbrugge and Jette (1994) emphasized the mediating role of various intra- and extra-individual factors in the pathway from pathology (i.e., disease) to disability. According to

their disablement process model, the racial disability gap stems not only from chronic conditions but also from various individual and social factors such as SES, health behaviors, built environment, and health care access, as well as prejudice and discrimination. Verbrugge and Jette further state that the difference in chronic health conditions among races is not a direct representation of biological differences but rather the result of interaction among various individual, social, and environmental characteristics.

Most studies have found that chronic disease is not as important as SES in explaining the black/white disability gap, as the racial disability gap was still present after controlling for chronic disease (Dunlop et al., 2007; Moody-Ayers et al., 2005; Ozawa & Yeo, 2008; Song et al., 2007; Taylor, 2008). For example, Dunlop and colleagues (2007) reported the hazard ratio for blacks for developing ADL disability was slightly decreased from 1.57 to 1.50 by including chronic disease variables as a mediator. However, Zsembik and colleagues (2009) found that the higher level of disability among older black adults vs. older white adults primarily stemmed from the greater prevalence of chronic disease and severe cognitive limitation in older black adults. They also found that the impact of medical conditions on disability was larger for older black adults. Kelley-Moore and Ferraro (2004) also reported that the incidence of chronic disease accounted greatly for the black/white disability gap. Several researchers have examined whether the black/white disability gap changes with increased age. Many studies have reported a decrease in the black/white disability gap as older adults age, and among the oldest adults, the disability crossover phenomenon has been observed (Johnson, 2000; Mendes de Leon et al., 1996). However, a few studies reported that the disability gap continued through to the oldest ages (Hayward et al., 2000; Kelley-Moore & Ferraro, 2004). Most studies identified SES as the leading cause of the black/white

disability gap, and that health behaviors and diseases are also contributing factors. However, the magnitude of the contribution of each of these factors (i.e., SES, health behaviors, and diseases) to the disability gap varied in each study.

Critique of Research Methods

As Kelley-Moore and Ferraro (2004) noted, the inconsistency in outcomes stems mostly from variations in the data and methods used by previous researchers. Previous studies have examined the black/white disability gap by focusing on disability prevalence, disability severity, disability onset, the risk of becoming disabled, and changes in disability severity.⁶ The nature of the data (i.e., cross-sectional or longitudinal) and disability measures (i.e., dichotomous or continuous) have varied across studies. This section summarizes and critiques the research methods used in previous studies according to study design, data and sample, measurement of disability, inclusion of covariates, and statistical methods. Limitations of earlier approaches and directions for future studies are also discussed.

Study design. Many of the earlier studies relied heavily on cross-sectional data (e.g., Fuller-Thomson et al., 2009; Ozawa & Yeo, 2008). The major limitation of cross-sectional studies is that they cannot confirm directionality, and the direction of effects can be the opposite of what is assumed. This limitation is especially critical in examining how various factors influence disability; the black/white disability gap among older adults could be caused by factors that are behavioral, socio-economic, or environmental in nature. Although analyses based on cross-sectional data can reveal associations between disability and these related factors, they cannot confirm that these factors contributed to disability. For example, Jang, Haley, Mortimer, and Small (2003) found that social support was significantly and positively related to the presence of disability among the elderly based on cross-sectional

⁶ See Appendix A for details

data. One cannot conclude from this study that a higher level of social support causes disability, as it is possible that the elderly with disabilities received a higher level of social support because of their needs. Another important limitation with using cross-sectional data is that it fails to incorporate the effects of selective mortality (Ferraro & Farmer, 1996; Kelley-Moore & Ferraro, 2004). In other words, cross-sectional data do not account for the higher mortality rates experienced by blacks. Accordingly, researchers' reliance on cross-sectional data likely underestimates the size of the black/white disability gap because the sample they have drawn from is more likely to be healthier (Ferraro & Farmer, 1996; Kelley-Moore & Ferraro, 2004). It appears that studies using cross-sectional data are useful in estimating disability prevalence and severity. However, cross-sectional studies are highly limited because they do not determine causality and do not address the issue of selective mortality. Therefore, it is strongly recommended that when studying the black/white disability gap, researchers use longitudinal data to examine the risk of disability onset or changes in disability severity over time.

Data and sample. Sample representativeness also contributed to inconsistent findings among studies of the black/white disability gap among older adults. Although many studies used nationally representative samples such as AHEAD and HRS, (Dunlop et al., 2007; Hayward et al., 2000; Kingston & Smith, 1997; Liang et al., 2009; Moody-Ayers et al., 2005; Ozawa & Yeo, 2008; Popa et al., 2007; Reynolds & Silverstein, 2003; Song et al., 2007; Zsembik et al., 2000) and the U.S. Census Bureau's American Community Survey (Fuller-Thomson et al., 2009), several studies used regional samples such as the North Carolina Established Populations for the Epidemiologic Studies of the Elderly (EPESE) (Guralnik et al., 1993; Kelley-Moore & Ferraro, 2004; Mendes de Leon et al., 2001; Taylor, 2008), the

California Health Interview Surveys (CHIS) (August & Sorkin, 2010), or data from the Chicago Health and Aging Project (Mendes de Leon et al., 2005). Although data from regional samples often provide more in-depth information on health (e.g., physical tests such as grasp strength), they present a major drawback. The proportion of the population that is minorities varies by region and thus cannot be assumed to be representative of the entire U.S. population. Also, characteristics of an older adult regional sample are not identical to those of the U.S. older adult population as a whole. Therefore, the findings from regional data are limited in that they cannot be generalized to the entire U.S. older adult population. To correctly estimate the black/white disability gap in the United States, a nationally representative sample must be used.

Disability measurements. Disability measurements were not consistent among studies. Most studies reviewed for this dissertation research utilized ADLs to measure disability (Dunlop et al., 2007; Fuller-Thompson et al., 2009; Kelley-Moore & Ferraro, 2004; Moody-Ayers et al., 2005; Song et al., 2007), and many studies further examined IADLs in addition to ADLs (Johnson, 2000; Liang et al., 2009; Ozawa & Yeo, 2008; Reynolds & Silverstein, 2003; Taylor, 2008; Zsembik et al., 2000). Unlike most researchers, Clark (1996) used Nagi's functional limitation indicators to measure disability. However, functional limitation indicators are not an appropriate way to measure disability because the disablement process model clearly separates disability (e.g., difficulties with ADLs and IADLs) from functional limitation.

The use of both ADLs and IADLs to measure disability is recommended by the disablement process model (Verbrugge & Jette, 1994). Although IADLs represent more complex tasks than ADLs, both types of tasks are still required to maintain independent

living. For example, even though using a telephone, shopping for groceries, and preparing a meal are considered IADLs, making a phone call can save one's life, and shopping for food and cooking may prevent malnutrition, especially for older persons. Further, many national family caregiver support programs and state-funded programs have adopted IADLs (in addition to ADLs) to evaluate eligibility.⁷ Therefore, examination of the black/white disability gap using indicators of both ADL and IADL disability will provide a broader and more comprehensive view of disability, which is important for policy and practice contexts.

Some studies measured disability in a dichotomous way—for example, dividing the sample into persons with at least one ADL disability vs. persons with no ADL disability (August & Sorkin, 2010; Dunlop et al., 2007; Fuller-Thomson et al., 2009; Hayward et al., 2000; Kingston & Smith, 1997; Moody-Ayers et al., 2005; Ozawa & Yeo, 2008; Reynolds & Silverstein, 2003; Song et al., 2007). Others measured disability in a continuous manner, by using total ADL score as a continuous variable, for example (Johnson, 2000; Kelly-Moore & Ferraro, 2004; Liang et al., 2009; Mendes de Leon et al., 2005; Popa et al., 2007; Taylor, 2008; Zsembik et al., 2000). The selection of dichotomous vs. continuous measures of disability was based on the study's research questions. Generally, if the study investigated prevalence, onset, or risk of disability, a dichotomous measure was adopted. Studies investigating severity or trajectory (change in severity over time) employed a continuous measure of disability.

Using a dichotomous measure can be advantageous in a longitudinal study because it highlights the stage when a participant becomes disabled. In contrast, a continuous measure

⁷ Examples are Alabama Cares, family caregiver support programs in Arizona and Florida, non-medical home and community-based services in Arizona, in-home supportive services in California, elderly and physical disabilities waiver in Washington, DC, home services program in Illinois, home- and community-based frail elder waiver and senior care act program in Kansas (Caregiver, 2010).

of disability should be applied when a study investigates the change in disability severity over time because a continuous measure accounts for all degrees of disability severity. The major drawback of the continuous approach, however, is that it assumes constant and linear change across different levels of severity.

Measurement of independent variables. To examine the black/white disability gap among older adults, researchers have included a variety of control variables or control factors. In general, these variables can be grouped into four categories: demographics (race, age, gender, marital/living status), disease, health behaviors, and socioeconomic status (SES). Although many studies included all four factors as covariates in their analyses, some studies used a very limited number of covariates. For example, Clark (1997) included age and gender as the only covariates to examine the black/white gap in disability prevalence between 1982 and 1989. Other studies included demographics and SES as covariates but ignored disease and health behaviors (Fuller-Thomson et al., 2009, Guralnki et al., 1993; Mendes de Leon et al., 2005, Ozawa & Yeo, 2008; Schoeni et al., 2005). Liang and colleagues (2009) included self-rated health and diseases as covariates but did not include any measures of SES and health behaviors

Most studies included individual chronic conditions (e.g., arthritis, diabetes, hypertension, cancer, heart disease) as covariates. However, a few researchers (August & Sorkin, 2010; Clark, 1996) used an aggregate variable for disease: they developed a chronic disease severity scale by summing the number of existing chronic conditions and used this scale as a covariate. Using individual chronic conditions as covariates instead of developing a severity scale is preferred because the influence of each chronic condition on disability differs according to the type of condition. For example, mental or psychological problems

could be related more significantly to disability than diabetes. Using a severity scale cannot adjust for the relative importance of each type of chronic condition.

The most commonly used measures of health behaviors in the literature are body mass index (BMI) (Andresen & Brownson, 1999; Dunlop et al., 2007; Hayward et al., 2007; Johnson, 2000; Song et al., 2007; Zsembik et al., 2000), physical exercise or activity (Andresen & Brownson, 1999; Clark, 1996; Dunlop et al., 2007; Hayward et al., 2007; Song et al., 2007; Zsembik et al., 2000), and smoking (Dunlop et al., 2007; Hayward et al., 2007; Moody-Ayers et al., 2005; Reynolds & Silverstein, 2003; Song et al., 2007; Taylor, 2008). Some studies also included alcohol use as a covariate (Dunlop et al., 2007; Popa et al., 2007; Song et al., 2007). Unlike disease and SES, health behavior variables have not been widely used in studies because of data limitations.

To measure SES, most studies included the respondent's level of education and income. Some studies expanded the SES factor by including assets or net worth (Dunlop et al., 2007; Hayward et al., 2000; Johnson, 2000; Kelly-Moore & Ferraro, 2004; Ozawa & Yeo, 2008; Reynolds & Silverstein, 2003; Song et al., 2007), home ownership (Taylor, 2008), employment (Hayward et al., 2000; Kelly-Moore & Ferraro, 2004), earlier occupation prestige (Kelly-Moore & Ferraro, 2004; Mendes de Leon et al., 2005), and poverty index (Fuller-Thompson et al., 2009). Interestingly, Dunlop and colleagues (2007) included type of health insurance as an indicator of SES.

Some studies also included covariates such as English fluency (August & Sorkin, 2010; Dunlop et al., 2007; Song et al., 2007), self-rated health (August & Sorkin, 2010; Clark 1996; Popa et al., 2007; Moody-Ayers et al., 2005), residency setting (e.g., rural, urban, metropolitan) (Johnson, 2000; Kelly-Moore & Ferraro, 2004), family network (Reynolds &

Silverstein, 2003; Kelly-Moore & Ferraro, 2004), social services use (Reynolds & Silverstein, 2003), religious service attendance (Kelly-Moore & Ferraro, 2004), home modification (Reynolds & Silverstein, 2003; Zsembik et al., 2000), and health care utilization such as doctor visits (August & Sorkin, 2010; Taylor, 2008). As the disablement process model posits, home and neighborhood environment, social services use, and health care utilization significantly influence each of the four stages of disablement (i.e., pathology, impairments, functional limitations, and disability). However, most studies failed to include these important variables because of data limitations, especially studies that used public data sets.

Statistical methods. Researchers have adopted several types of statistical tools to examine the black/white disability gap, with their selections depending upon their data collection methods and primary research questions (e.g., prevalence, onset, or severity of disability). When studies used cross-sectional data to investigate the black/white disability gap, logistic or probit models were typically used to analyze prevalence (August & Sorkin, 2010; Fuller-Thomson et al., 2009; Kingston & Smith, 1997; Moody-Ayers, et al., 2005; Ozawa & Yeo, 2008; Reynolds & Silverstein, 2003), while OLS regression was often used to analyze severity (Johnson, 2000; Zsembik et al., 2000). Researchers who utilized longitudinal data most commonly used survival analysis when focusing on the timing of disability onset (Dunlop et al., 2007; Hayward et al., 2000; Song et al., 2007), growth models when focusing on changes in severity (Kelly-Moore & Ferraro, 2004; Mendes de Leon et al., 2005; Popa et al., 2007; Taylor, 2008), and group-based mixture models when focusing on changes in individual membership of disability groups (Liang et al., 2009). As would be expected, given the large variation in analytical methods, findings have not been identical. For example, Taylor (2011) found that higher education levels were preventive for disability

onset but did not affect disability severity, whereas financial resources affected the trajectory of disability but not onset. Therefore, it is important to note that findings regarding the black/white disability gap and the factors that influence it may vary depending on the type of statistical analysis used.

The limitations, inconsistencies, and differing results of previous studies underscore the need for a more comprehensive investigation of the black/white disability gap utilizing longitudinal data from a nationally representative sample over an extended period of time.. Furthermore, although there have been an increasing number of studies focusing on the racial disability gap among older adults, most of these studies included only adults ages 65 and older or ages 70 and older. Studies that include adults approaching older age (i.e., ages 50 to 64) are scarce. An investigation of adults ages 50 and older will provide a more comprehensive examination of the black/white disability gap. More importantly, most previous studies examined the black/white disability gap using aggregate measures of ADLs and IADLs. Among the research reviewed for this dissertation study, only one published study (Reynolds & Silverstein, 2003) investigated individual ADL disability indicators. No study has investigated individual IADL indicators. Therefore, the black/white disability gap for each ADL and IADL indicator is still unknown.

This dissertation study can be regarded as an extension of the study by Ozawa and Yeo (2008) that examined the relationship between the racial disability gap and SES in the older adult population. However, this dissertation study differs significantly Ozawa and Yeo's study in the many ways. Ozawa and Yeo focused on disability prevalence and used cross-sectional data. Therefore, Ozawa and Yeo could not address the change in the racial disability gap as respondents aged, nor could they address the racial gap in the risk of

developing a disability. This dissertation study focuses on disability risk and uses 11 years of longitudinal data. This dissertation study also addresses the change in the racial disability gap as respondents aged. Ozawa and Yeo employed logistic regression because they used cross-sectional data. This dissertation study employs Cox regression to analyze longitudinal data. Ozawa and Yeo measured disability by using aggregated measures of ADLs and IADLs (i.e., one or more ADL disabilities vs. none, one or more IADL disabilities vs. none). This dissertation study investigates each ADL and IADL disability indicator individually. Ozawa and Yeo's sample included adults ages 62 and older. The sample for this dissertation study includes non-disabled adults ages 50 and older. Finally, this dissertation study includes a more comprehensive set of covariates (i.e., health behaviors and diseases in addition to SES) than Ozawa and Yeo's study.

Conceptual Framework of the Study

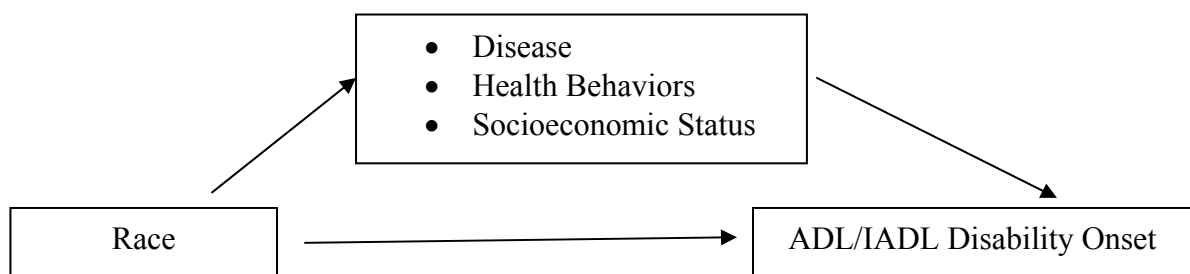
As previously stated, the disablement process model by Verbrugge and Jette (1994) has served as an important guide for research in aging and disability (e.g., Jang et al., 2003; Janke, Payne, & Puymbroeck, 2008; Porell & Miltiades, 2001) as well as research examining the racial disability gap among older adults (e.g., Song et al., 2007; Zsembik et al., 2000). Although the disablement process model does not provide a clear explanation for the disability gap that exists between older black and white adults, the model implies that each group may experience developing and living with a disability differently, with various mediating factors playing a key role in this difference.

Guided by the disablement process model (Verbrugge & Jette, 1994), disability in this dissertation study is defined as having one or more physical or mental limitations in performing socially demanding roles created by physical and cultural environments.

Disability is assessed by ADLs and IADLs, criteria that have been widely used in previous studies to assess disability in later life. The use of ADLs and IADLs to measure disability is also recommended by the disablement process model (Verbrugge & Jette, 1994). This dissertation study focuses on differences in disability onset between community-dwelling older black (non-Hispanic) and white (non-Hispanic) adults ages 50 and older in the U.S. by investigating each indicator of ADL and IADL disability on an individual basis. In addition, this study examines the mediators that account for the differences between these two groups. Specifically, it examines the role of three possible mediating factors—chronic disease, health behaviors, and socioeconomic status—to explain the black/white gap in disability onset.

Figure 2 depicts the conceptual framework used in this study. According to this framework, disease, health behaviors, and SES are mediators that connect race with the onset of each ADL or IADL disability (outcome). This mediation model seeks to identify and explicate the mechanism that underlies an observed relationship between race and the onset of ADL or IADL disability by the inclusion of three mediating factors.

Figure 2. The Conceptual Framework of the Study



Based on this conceptual framework, this study focuses on the following two research questions.

Research Question 1: Is there a difference in the risk of disability onset between non-Hispanic white adults and non-Hispanic black adults ages 50 and older? Does it change with advancing age?

Research Question 2: If so, to what extent do chronic disease, health behaviors, and SES contribute to the gap in the risk of disability onset between these two groups?

To answer these two research questions, this study investigates each of the 12 ADL and IADL indicators individually when measuring disability instead of aggregating ADL and IADL indicators, which was the method employed in previous studies.

Regarding Research Question 1, earlier studies on the black/white disability gap consistently reported that older black persons were more likely to be disabled than older white persons (Hayward et al., 2000; Kelley-Moore & Ferraro, 2004). Therefore, this study hypothesizes that the risk of disability onset will differ for older non-Hispanic white adults vs. older non-Hispanic black adults according to most disability indicators (i.e., the 12 ADL and IADL indicators examined in this study). It is expected that older whites will have a lower risk of becoming disabled than older blacks.

For Research Question 2, this study hypothesizes that chronic diseases, health behaviors, and socioeconomic status contribute to narrowing the black/white disability gap to some degree. In line with existing research (Kelley-Moore & Ferraro, 2004; Song et al., 2007; Mendes de Leon et al., 2005; Taylor, 2008), it is expected that SES will emerge as the most important factor explaining the black/white gap in disability onset in older adults. Chronic disease and health behaviors are also expected to contribute to this racial gap to some degree (Dunlop et al., 2007; Kelly-Moore & Ferraro, 2004; Song et al., 2007).

Although many studies have focused on the racial gap in disability in older adults, this study is distinct in many ways. First, most previous studies investigated the black/white disability gap using aggregated measures of ADLs and IADLs. This dissertation study will investigate each ADL and IADL indicator separately. Second, the study uses a nationally representative sample with 11 years of longitudinal data, and it also employs advanced statistical techniques (e.g., survival analysis with age as time scale). Third, most studies limited their samples to the elderly (e.g., ages 62 and older or 65 and older). By expanding the study sample to including adults ages 50 and older, the racial disability gap can be understood in a more comprehensive way. Fourth, there is also a lack of knowledge regarding the black/white gap in the risk of disability onset. While many studies have investigated the black/white gap in disability prevalence or disability severity, only a few (Dunlop et al., 2007; Hayward et al., 2000; Song et al., 2007) have investigated the racial gap via the timing of disability onset. Furthermore, the few studies that did focus on the timing of disability onset did not explore each ADLIADL indicator individually and had shorter study periods (2 to 6 years).

CHAPTER 4

RESEARCH METHODS

Data

This study used six waves of longitudinal data from the RAND Health and Retirement Study (HRS) collected between 1998 and 2008. Conducted by the University of Michigan with the support from the National Institute on Aging, the HRS has collected data on various measures, especially health and disability, assets and income, health behaviors, employment, and retirement. The HRS is a biennial (once every two years) panel survey of a nationally representative sample of non-institutionalized Americans ages 50 and older. Its main goal is to provide longitudinal data for research to support the creation of effective policies on retirement, health, and economic well-being of older adults in the U.S. (National Institute on Aging, 2007).

The HRS was launched in 1992 with an original cohort sample of individuals ages 51 to 61. In 1998, HRS expanded to create a nationally representative sample of U.S. older adults ages 50 and older by adding three cohorts—the oldest cohort (persons born before 1924), the children of the Great Depression cohort (born between 1924 and 1930), and the World War II baby cohort (born between 1948 and 1953)—to its initial HRS cohort.

Because of the complexity of the HRS raw data (e.g., missing data and inconsistent measuring of variables across waves, which makes it difficult to match respondent characteristics across years), the RAND Corporation, with the support of the Social Security

Administration and the National Institute on Aging, developed the RAND HRS, a user-friendly version of the HRS with a subset of important variables from the original HRS. In creating RAND HRS, the RAND Corporation has undertaken extensive efforts to make the data uniform and accessible to researchers, include cleaning and checking the consistency of data across waves, missing data imputation (especially for financial measures⁸), and using bracketing methods to minimize non-response and matching structure of variables across waves. The RAND HRS is a leading source of research on the older population of the U.S. because of the richness of the original HRS and the relative ease of access to the data (Phillips, 2003/2004). As of December 2010, the RAND HRS is publicly available from wave 1 (collected in 1992) to wave 9 (collected in 2008).

This study utilized the RAND HRS to explore the black/white disability gap for the following reasons. First, the data encompasses a lengthy study period and has a nationally representative sample. Second, the data contains the most relevant variables, such as various chronic disease and health behavior measures, as well as information about net worth, which provides a more comprehensive measure of respondents' SES. Third, the data provides the most complete information on ADL and IADL indicators for all waves. Fourth, the RAND HRS has been widely used in previous studies on the topic of health and disability among older adults. This study used the RAND HRS from wave 4 (collected in 1998) through wave 9 (collected in 2008) because the sample from the earlier waves included only the initial HRS sample, which was limited to persons ages 51 to 61.

Sample

The RAND HRS wave 4 included 18,104 non-institutionalized adults ages 50 and

⁸ For the detailed information on missing data imputation by the RAND HRS, see the technical document, "RAND HRS 2008 Income and Wealth Imputations" (RAND, 2010).

older: 2,774 non-Hispanic blacks and 15,530 non-Hispanic whites. Because this dissertation study focused on the timing of disability onset since age 50, the study sample was restricted to respondents who were not disabled (i.e., respondents without any limitations in ADLs/IADLs) in wave 4, which decreased the sample to 13,447 respondents (11,693 whites and 1,765 blacks).

This study is designed to use time-varying covariates for most variables, which requires complete records of variables from wave 4 until the wave in which disability onset or censoring⁹ occurs. Although the RAND HRS provided the most complete information across all waves owing to RAND's extensive cleaning of the HRS raw data and imputation of missing data, a small number of missing values were still present in the RAND HRS data. The percentage of missing values for the independent variables ranged from 0% (entering cohort, gender, living status, income, and net worth) to 1.3% (BMI) of the 13,447 respondents in wave 4. The proportion of missing cases was similar across all study waves (i.e., waves 4 to 9).

To deal with these missing values, this study adopted forward imputation (also called carry-forward imputation), which replaced missing values with the values from the previous waves. Forward imputation was selected according to the following rationale. First, it is a feasible and credible strategy and it protects the dependence between an outcome and a covariate with missing imputation (Singer & Willett, 2003). Second, this method has been recommended and widely employed in previous studies using HRS/RAND HRS data (e.g., Doshi, Cen, & Polsky, 2008; Feinglass et al., 2007; Hoffmann, 2005; Lachance & Seligman, 2009). Third, list-wide deletion resulted in inconsistent samples across all study outcomes

⁹ Censoring occurs when the value of a variable or measurement is only partially known. In this study, censoring occurs when a study participant drops out or when wave 9 is reached.

(i.e., all 12 disability indicators) because the timing of onset was different among each disability outcome. Fourth, the results from sensitivity analyses with a list-wide deleted sample for two study outcomes (the ADL indicator walking across a room and the IADL indicator using a map) were very similar to those of Cox models with a forward-imputed sample. Therefore, the decision was made to use the forward-imputed sample.

Of the 13,447 respondents, 29 (0.001%) were deleted from the sample because of missing cases on covariates¹⁰ even after performing forward imputation. Removal of the missing cases was not likely to affect the study results because the number of missing cases is relatively small given the size of the total sample. The final sample size for this study was determined to be 13,429 respondents (11,673 whites and 1,756 blacks).¹¹

Censoring, Study Window, and Time Origin

In survival analysis, there are three types of censoring which occur when the timing of the event of interest is unknown. First, *left censoring* occurs when an individual experiences the event of interest, but it is unknown when the event started. In other words, the event of interest occurs before the start of the observation period. Second, *right censoring* occurs when an individual has the event of interest after the end of observation period. Third, *random censoring* indicates when an individual has the event of interest after he or she dropped from the sample because of loss of contact or death.

This study did not have left censoring cases since the study sample was limited to the respondents who were not disabled at baseline (i.e., wave 4). However, the majority of the study sample was right- or random-censored cases. The right censoring in this study refers to the respondents who did not experience a disability by the wave 9. Across the 12 study

¹⁰ Missing cases included 28 BMI, 1 hypertension, 1 lung disease, 3 heart disease, 1 stroke, 2 arthritis, and 12 education records.

¹¹ The weighted sample size is 47,287,028 (43,415,756 whites and 3,896,509 blacks).

outcomes, the proportion of right-censored cases ranged from 54.6% (difficulty with using a map) to 64.8% (difficulty with eating) of the total sample (n=13,429). The random censoring in this study refers to the respondents who dropped out of the sample (due to death, refusal to participate, or failure to locate for follow-up interviews) before wave 9 and had not experienced a disability before they dropped out. This proportion ranged from 26.7% (difficulty with dressing) to 29.5% (difficulty with eating) of the total sample.

Random censoring is problematic if it is informative (i.e., it provides information on the risk of disability). This study conducted sensitivity analysis by testing two extreme assumptions about random censoring. One assumption was that the random-censored individuals became disabled immediately after they were censored. The other assumption was that the random-censored individuals had longer times until becoming disabled than anyone else in the sample (Allison, 1995). For most cases, sensitivity analysis produced similar results as the results reported in this study.¹² Thus, it is reasonably certain that we can treat random-censored cases as non-informative censoring cases. There were also other reasons for including the random-censored cases in the final sample. First, previous studies using survival analysis to examine the timing of disability generally treated random-censored cases as non-informative cases and these random-censored cases were included in their sample (Dunlop et al., 2007; Song et al., 2007). Second, removing random-censored cases resulted in sample inconsistency across all disability outcomes. Third, logistic regression found there was no significant difference in random-censored cases between the black and white respondents.

This dissertation study employs a respondent's age itself as the time scale, which is

¹² Please refer to Appendix B regarding the results from sensitivity analysis for the assumption of disabled immediately after being censored.

known as the time in age approach. Following the time in age approach, the study window for this study extended from age 50 (the minimum age of a respondent at wave 4) to age 103 (the maximum age of a respondent who reported a disability or was censored). The origin of time was determined to be age 50. Further information about the time scale is provided in the data analysis section.

Measures

Dependent variables. Disability in this study was defined as the individual's inability to work and fulfill social roles because of health problems, a definition based on the disablement process model (Verbrugge & Jette, 1994). Disability is measured by ADLs and IADLs, which corresponds to the definition of disability in the disablement process model. The RAND HRS included six items from ADL instruments developed by Katz and colleagues (Katz, Ford, Moskowitz, Jackson & Jaffe, 1963). The RAND HRS also contains a set of IADL indicators borrowed from the IADL inventory developed by Lawton and Brody (1969). Among the various IADL indicators included the RAND HRS, six were consistently measured in waves 4 through 9.¹³

ADL indicators in this study include: 1) difficulty walking across a room, 2) difficulty with dressing, including putting on socks and shoes, 3) difficulty with bathing or showering, 4) difficulty with eating such as cutting up food, 5) difficulty getting in and out of bed, and 6) difficulty with using the toilet, including getting up and down. IADL indicators include: 1) difficulty using a map to figure out how to get around in a strange place, 2) difficulty making a phone call, 3) difficulty with taking medications, 4) difficulty managing money, such as paying bills and keeping track of expenses, 5) difficulty with shopping for groceries, and 6)

¹³ Previous RAND HRS waves included a few additional IADL indicators such as “difficulty with using a calculator,” “difficulty with using a computer,” and “difficulty with using a microwave.”

difficulty with preparing hot meals.

For each indicator, the respondent was asked, “Because of a physical, mental, emotional or memory problem, do you have any difficulty with . . . ? Exclude any difficulties you expect to last less than three months.” There were four response options for each question: *Yes*, *No*, *Don’t do*, and *Can’t do*. For responses of *Don’t do* or *Can’t do*, a follow-up question was asked to determine whether the difficulty was due to a health or memory problem.

Each of the twelve ADL and IADL indicators were dichotomized in the following way. The respondents were determined to be disabled (coded 1) if they had a difficulty with a specific task. The respondents who answered *Don’t do* or *Can’t do* because of health or memory problems were also coded as being disabled. Otherwise they were coded 0, indicating no disability. Respondents who were not disabled at wave 9 or when the observation was terminated were coded as censored cases.

This dissertation study included 12 dependent variables, one for each ADL and IADL indicator. Each dependent variable was defined to the time of the event of interest (i.e., a determination of disability) or to the time when censoring occurred.

Independent variables. This study included various individual characteristics as covariates. Most of the covariates (i.e., all disease variables, all health behavior variables, and the SES variables of income and net worth) were one-wave lagged time-varying covariates. That is, the measuring point of each covariate was one wave before the measuring point of the outcome. However, entering cohort, race, gender and education were time-constant covariates. That is, the value of a covariate remained the same throughout the study period.

Race included two categories: non-Hispanic white (reference) and non-Hispanic black. *Entering cohort*—that is, the respondent’s age at the RAND HRS wave 4—was divided into four categories: ages 50–59 (reference), ages 60–69, ages 70–79, and ages 80 and older. By using age as time scale and adjusting for late entry in the Cox regression, the effect of age on an outcome is absorbed entirely into the baseline hazard function (Singer & Willett, 2002). However, inclusion of entering cohort information in the analysis is still important to control for cohort effects referring to generational effects (Guo, 2010) and to produce more precise coefficients of other independent variables (Singer & Willett, 2002). *Gender* was a dichotomous variable: men were coded as 1 and women were coded as 0 (reference). *Living status* had three categories: living alone, living with a spouse or partner (reference), and living with others. Respondents living with a spouse and others were classified as living with a spouse.

The chronic disease factor covered the following eight self-reported measures: 1) high blood pressure or hypertension, 2) diabetes or high blood sugar, 3) cancer or a malignant tumor of any kind except skin cancer, 4) chronic lung diseases except asthma, 5) heart attack, coronary heart disease, angina, congestive heart failure, or other heart problem, 6) stroke or transient ischemic attack, 7) memory-related disease or emotional, nervous, or psychiatric problems, and 8) arthritis or rheumatism. For each measure, the respondent was asked, “Since the last interview, has a doctor told you that you have . . . ?” The definition of doctor included general practitioners, family doctors, and physician assistants as well as specialists such as psychiatrists and dermatologists. These eight chronic disease variables were dichotomous measures. If a respondent had a doctor’s diagnosis for a given disease, he or she was coded as 1; others were coded as 0 (reference).

This study included four health behavior measures to represent the health behavior factor: body mass index, alcohol consumption, current smoking behavior, and vigorous physical activity. *Body mass index (BMI)* is an index of weight adjusted for height. Higher values indicate excessive fat storage. Body mass index was calculated by dividing weight (in kilograms) by height (in meters squared) and then multiplying by 100. Respondents were placed into one of four categories developed by the National Institutes of Health: underweight ($BMI \leq 18.5$), normal weight (18.5–24.9, reference), overweight (25–29.9), and obese (≥ 30). Respondents were also asked about quantity and frequency of *alcohol use*. Following guidelines from the National Institute on Alcohol Abuse and Alcoholism (NIAAA, 2005), three categories of alcohol use were developed: none (reference), light to moderate, and heavy. Light to moderate drinkers were those who had less than 15 drinks per week and 3 or less drinks per drinking day (4 or less drinks for men). Those who had 15 or more drinks per week or more than 3 drinks per drinking day (more than 4 drinks for men) were classified as heavy drinkers. *Vigorous activity* was measured dichotomously. Respondents were asked, “On average, over the last 12 months, have you participated in vigorous physical activity or exercise three times a week or more?” Vigorous physical activity included sports, heavy housework, or a job involving physical labor. The categories were Yes or No (reference). *Smoking* was a dichotomous measure based on the survey question, “Do you smoke cigarettes now?” The current smokers were coded 1, and non-smokers were coded 0 (reference).

The SES factor was represented by the following three variables: level of education, total household income, and total household net worth. *Level of education* was divided into four categories: less than high school graduate (reference), high school graduate or GED,

some college, and bachelor's degree or more. *Total annual gross household income* was constructed from an extensive series of self-reported responses about various types of income such as wages, household capital income, pensions, social security, and government transfers. To reduce item non-response on financial measures, the HRS used special techniques such as bracketing and flash cards. Total household income was log transformed and treated as a continuous variable because its distribution was skewed with a long right tail. To adjust to economic inflation during the study period (1998 – 2008), household income for each wave was adjusted to the 1998 dollar value using the Consumer Price Index (CPI). It is important to note that the RAND HRS calculations of household income included the income of the respondent and spouse/partner only. This measure did not include income from other household members. This study used total household income rather than per capita personal income (i.e., total household income divided by the number of household members) for the following reasons. First, total household income captures more expansively the socioeconomic status of an older respondent. Perhaps because of this, total household income has been more widely used in previous studies of disability among older adults (e.g., Moody-Ayers, 2005; Song et al., 2007; Taylor, 2010). Second, this study included living status (living alone, living with a spouse, or living with others) as a covariate. Therefore, the coefficient of the total household income from a regression model was automatically adjusted by the household size. *Total household net worth* is defined as total assets minus total debts. The RAND HRS covered various components of assets, such as real estate (including primary and secondary residences), vehicles, and business and financial assets (e.g., IRAs, stocks, funds, bonds, and checking and savings accounts). Debts included mortgages, home loans, and other debts. Although the distribution of total household net worth was sparse with

a long tail on both ends, log or square root transformation was not applicable because of the presence of negative values. To resolve the influence of extreme outliers, total household net worth was categorized by quintile (Mermin, Zedlewski, & Toohey, 2008; Mishra & Dilip, 2008; Rodriguez, Diaz-Gimenez, Quadrini, & Rios-Rull, 2002). The lowest quintile was used as a reference group.

Data Analysis

Descriptive analyses. Univariate and bivariate analyses were conducted to describe the study sample and to evaluate the differences in characteristics between black and white respondents. The differences between the two groups were evaluated by t-tests for continuous measures and chi-square tests for categorical measures. Results are displayed in Table 1. To explore bivariate relationships between independent variables and outcome measures (i.e., the timing of each disability onset), median survival ages using the Kaplan–Meier product-limit estimates were calculated. Results are shown in Table 2.

Regarding Research Question 1 regarding the differences in the risk of disability between black and white respondents, the Kaplan-Meier estimates were used to describe and explore the events of interest (i.e., the onset of each disability indicator) by obtaining plots of the survivor and hazard functions. Survivor function is the probability that respondents will not experience the onset of a disability at a certain age. Hazard function is the conditional probability that a respondent will experience a disability onset at a certain age, given that the respondent did not experience a disabling condition in any earlier study period.

The differences in survivor function by race were evaluated by the following tests: Cox-based Wald χ^2 statistics with appropriate sampling weights, and log-rank tests without sampling weights. The median and the 25th percentile of survivor function, as well as a

disability incidence rate for each group, are provided in Table 3.

Cox regression. This study employed survival analysis to test the mediation models discussed in the following section. Survival analysis is the most suitable statistical tool when a research question is concerned with whether and when an event occurs. Survival analysis is also the most applicable statistical tool for analyzing time-to-event data because of its ability to cope with censored data, as the event of interest may not always be observed. For example, some respondents did not experience a disability by the end of study period. These right-censored cases cannot be handled correctly by the conventional OLS method.

This dissertation study chose Cox regression among the various survival analysis techniques for the following reasons. First, Cox regression is considerably more robust (Allison, 1995) and more flexible (Tveteras & Eide, 1999) than other survival analysis tools because of its semiparametric nature (Allison, 1995). That is, Cox regression does not require knowing a particular probability distribution to represent survival times. Second, the application of time-varying covariates is relatively easy in Cox regression (Allison, 1995). Third, Cox regression permits testing interaction terms between time and covariates. Fourth, Cox regression is not as sensitive to missing values as other survival analysis tools because it does not require having complete information on a dependent variable during the entire study period. The lack of a requirement for complete records is also important advantage when time-varying covariates are used. Fifth, Cox regression has been widely applied in previous studies of disability and health-related outcomes among older adults (Kondo et al., 2009; Matthews et al., 2005).

Cox regression in this dissertation study specified the hazard of becoming disabled

for individual i at age t ¹⁴ as a function of a baseline hazard rate $\lambda_0(t)$, a vector of time constant covariates X , a vector of one-wave (i.e., two years) lagged time-varying covariates Z , and parameters β' .

$$h_i(t) = \lambda_0(t) \exp(X_i\beta' + Z_{it-2}\beta')$$

By taking the logarithm of both sides, the equation was simplified as

$$\log h_i(t) = \log \lambda_0(t) + X_i\beta' + Z_{it-2}\beta'$$

Where X = [entering cohort, race, gender, living status, education]; Z = [hypertension, diabetes, cancer, lung disease, heart disease, stroke, psychological or memory-related disease, arthritis, BMI, drinking, smoking, vigorous activity, income, net worth].

To remedy the causality concern (i.e., the directionality from time-varying covariates to disability outcomes), it is recommended to use a lagged predictor that is less likely to produce inferential problems caused by reciprocal causation (Singer & Willett, 2003; Winship & Sobel, 2001). Therefore, this study used one-wave lagged time-varying measures for all time-varying covariates (i.e., all disease variables, all health behavior variables, income, and net worth).

This study reported the hazard ratio instead of its coefficient. The hazard ratio is the exponential of its coefficient for each independent variable estimated by Cox regression. The advantage of reporting the hazard ratio is that its interpretation is more intuitive than its coefficient. A hazard ratio of less than 1 infers a negative percentage effect (e.g., 0.8 means 20% less), and a value greater than 1 infers a positive percentage effect (e.g., 3 means three times as likely as the reference group).

Mediation models. To answer Research Question 2 regarding the role of chronic

¹⁴ Age t is defined as the respondent's age minus 50. For example, the respondent age 50 was set to 0.

disease, health behaviors, and socioeconomic status in explaining the black/white disability gap, this study used a series of Cox regressions. The following equations briefly summarize the mediation models used.

Unadjusted model: $\log h_i(t) = \log \lambda_0(t) + \beta_1 Black_i$

Model 1: $\log h_i(t) = \log \lambda_0(t) + \beta_1 Black_i + DEMO_i \beta$

Model 2: $\log h_i(t) = \log \lambda_0(t) + \beta_1 Black_i + DEMO_i \beta + DISEASE_i \beta$

Model 3: $\log h_i(t) = \log \lambda_0(t) + \beta_1 Black_i + DEMO_i \beta + BEHAVIOR_i \beta$

Model 4: $\log h_i(t) = \log \lambda_0(t) + \beta_1 Black_i + DEMO_i \beta + SES_i \beta$

Model 5 (full model):

$$\log h_i(t) = \log \lambda_0(t) + \beta_1 Black_i + DEMO_i \beta + DISEASE_i \beta + BEHAVIOR_i \beta + SES_i \beta$$

where DEMO = [entering cohort, gender, living status]; DISEASE = [hypertension, diabetes cancer, lung disease, heart disease, stroke, psychological or memory-related disease, arthritis]; BEHAVIOR = [BMI, drinking, smoking, vigorous activity]; SES = [education, income, net worth].

The unadjusted model produced the hazard ratio of a black person becoming disabled without controlling for other covariates. Model 1 added demographic variables (entering cohort, gender, and living status) to the unadjusted model. Models 2, 3, and 4 added the chronic disease factor, the health behaviors factor, and the SES factor, respectively to Model 1. Model 5 included all covariates in the study. The aim of this series of analyses was to quantify the changes in the hazard ratio of black persons becoming disabled from Model 1 to each of the subsequent models. This statistical modeling (i.e., adding each factor to the base model) was often used in previous studies employing Cox regression to investigate the influence of mediating variables (e.g., Koster et al., 2006; Moody-Ayers et al., 2005). To

quantify the amount of gap narrowed by each factor, the percentage change in the hazard ratio for blacks of becoming disabled was calculated by comparing the hazard ratio in Model 1 with the hazard ratio in each subsequent model.¹⁵ The significant level of the hazard ratio of becoming disabled in each model was evaluated by the survey-based data analyses and the LWA models.¹⁶

Age as time scale and left truncation. In survival analysis, time scale is often defined by the elapsed time from entry into the study until the event occurs (time-in-study approach). Instead of using the time-in-study approach, this study used a respondent's age as a time scale (time-in-age approach) because the use of age as time scale in a survival analysis has been especially recommended for studies on the older population, given that age itself is strongly related to various health outcomes such as death, disability, and disease (Korn, Graubard, & Midthune, 1997; Lamarca, Alonso, Gomez, & Munoz, 1998).

By using age as time scale, the effect of age on disability was directly taken into account by adjusting automatically for the confounding effects of age and the aging process (Lamarca et al., 1998; Singer & Willett, 2003; Thiebaut & Benichou, 2004). More importantly, the time-in-age approach provides a more meaningful and practical interpretation by estimating individual inferences at a specific age (Allison, 1995; Lamarca et al., 1998). This study assigned age 50 as the time of origin because the study focuses on respondents ages 50 and older (Lamarca et al., 1998). The unit of time is years.

The data for this study presented late entrants, because respondents entered into the study at different ages. This study examined the hazard of disability onset starting at age 50. However, most of the individuals in the sample were already over 50 when they entered the

¹⁵ % change = (H.R. in Model 1 – H.R. in each subsequent model) / (1 – H. R. in Model 1) * 100.

¹⁶ The reliability model developed by Lee, Wei, Amato, better known as the LWA model, is discussed further in the section of this dissertation titled “Survey-based analyses and LWA models.”

study. These late entrants introduced “left truncation.” Without adjusting for these late entry cases in Cox regression, results are more likely to be biased (Pencina, Larson, & D’Agostino, 2007; Thiebaut & Benichou, 2004). Each respondent needs to be included in the risk set for a given age only if he or she is at risk of a disability occurrence at that age (Singer & Willett, 2003).

To adjust for these late entrants, this study used the extended Kaplan-Meier estimator by the *time0* option in the *stset* command to estimate median survival ages and to plot hazard/survival curves.¹⁷ By utilizing the *time0* option, each respondent contributed at the age in which they were actually recorded. Not all respondents are considered at risk at age 50 because they entered the baseline at a different age. When Cox regression was performed, delayed entry was also adjusted by using the *time0* option of the *stset* command (Lamarca et al., 1998; Matthews et al, 2005).

Survey-based analyses and LWA models. The RAND HRS is a multistage area probability sample with oversampling of minorities (i.e., blacks and Hispanics) and Florida residents. This complex sample design requires appropriate data analysis methods (i.e. survey-based analysis). The RAND HRS provides a person’s weight and strata information (52 clusters and 104 sampled primary stage units) to account for the unequal probability of selection by adjusting for geographic and racial group differences. Application of a standard analysis to the complex sample results in a biased estimated standard error (i.e., underestimation of variances of survey estimates of descriptive statistics and model parameters) because the analysis assumes simple random sampling and equivalent independence of observations. Consequently, a significance test based on this biased standard

¹⁷ A new variable ‘entryage’ was created to represent the actual age when a respondent entered the HRS wave 4 (the baseline of this study). Then *time0* (entryage – 50) was used in the *stset* command in Stata.

error produces an incorrect result. Following RAND HRS guidelines, this study employed survey-based data analyses using the *svyset* and *svy* prefixes in Stata (StataCorp, 2009) to produce a more robust result based on the survey-adjusted standard errors (i.e., Huber/White standard errors).

There is another concern for this study regarding a clustering structure of the data. It is reasonable to suspect that a respondent and his/her spouse share similar health behaviors and SES. Because they live in the same house, they may encounter the same barriers to ADLs and IADLs, as these barriers are highly influenced by housing conditions and neighborhood environment. That is, the data are likely to be clustered by each household. The WLW (Wei, Lin, and Weissfeld) model and the LWA (Lee, Wei, and Amato) model have been widely used to correct for autocorrelation caused by clustered data in Cox regression. The WLW model varies the baseline hazard function among types of failures, which is common in multiple failure data. In other words, clustering is an ordered nature (e.g., the hazard function of the first failure is different from that of the second failure). However, the LWA model assumes the same baseline hazard function for types of failures (Guo, 2010). Because the clustering structure in this study was not in an ordered nature, the LWA model was used with *cluster* and *robust* options in Stata to adjust for household clustering (n=9,942).

Because the survey-based analysis module in Stata does not allow implementing the LWA model at the same time as the Cox regression, the survey-based Cox regression and the LWA Cox regression were performed separately and the results from two approaches were compared to make sure the main findings of this study were reliable. The two approaches produced the same coefficients but with slightly different standard errors. This dissertation study was based on the survey-based Cox regression to be consistent with the previous

studies using the RAND HRS sample. The results from the LWA model are reported in Appendix D.

CHAPTER 5

RESULTS

The Results chapter is comprised of the following five sections: 1) model diagnostics tests of residuals, influencing outliers, and the proportional hazard assumption of the race variable (i.e., black vs. white); 2) univariate and bivariate analysis results including sample descriptions, tests of differences in sample characteristics between black and white respondents, and bivariate analyses between disability outcomes and a series of mediator variables; 3) bivariate analysis results about the relationship between race and disability outcomes, which addresses Research Question 1; 4) mediation analyses with a series of multivariate Cox regressions, which addresses Research Question 2; and 5) model-predicted survival and hazard curves based on the full model that included all covariates.

Model Diagnostics

To check whether the data are suitable to Cox regression, a series of model diagnostic tests were conducted. Diagnostic tests included multicollinearity tests by VIF, Deviance residual tests, influencing outlier tests by DFBETA, and tests of proportionality assumptions by Schoenfeld Residual.¹⁸

Diagnostic tests revealed that: 1) no covariates of this study presented multicollinearity problems; 2) there were no distinct extreme cases in any disability models; 3) the influences of outliers were minimal; and 4) a proportionality assumption of the race variable was met when all covariates were controlled, which implies independence between

¹⁸ See Appendix B for the test results of model diagnostics.

the race variable and time. In sum, diagnostic tests confirmed the appropriateness of the data for Cox regression.

Univariate and Bivariate Analysis Results

Table 1 reports descriptive characteristics of the study sample based on the baseline (HRS wave 4) characteristics. For the entire sample, the mean age was 64. The majority were women (52%) and living with a spouse (70%). Hypertension (42%) and arthritis (46%) were the most prevalent doctor-diagnosed diseases among the eight chronic disease variables. The majority of the sample did not drink (63%) or smoke (83%). About 40% were overweight, and half reported engaging in vigorous activity. The mean household income was \$60,948.

Black and white respondents were significantly different in most characteristics. Compared to white respondents, black respondents were about 1.2 years older ($p < .01$), more likely be male ($p < .05$) and less likely to live with a spouse ($p < .001$). There were no significant differences in the prevalence of stroke and arthritis between the two groups. Black respondents had a higher prevalence of hypertension ($p < .001$), diabetes ($p < .001$) and psychiatric or memory-related diseases ($p < .001$). White respondents had a higher prevalence of cancer ($p < .01$), lung disease ($p < .001$) and heart disease ($p < .01$). Smoking was more common among black respondents ($p < .001$). White respondents were more likely to be light to moderate drinkers ($p < .001$) and engage in vigorous activity ($p < .001$) compared with black respondents.

The most striking differences between the two groups were related to socioeconomic status. Black respondents had substantially lower socioeconomic backgrounds than white respondents. The prevalence of white respondents with an educational level of Bachelor's degree or more was about twice that of black respondents. The mean household income of

Table 1

Sample Characteristics by All, Black, and White Respondents in the RAND HRS Wave 4

<i>Characteristics</i>	<i>All (N=13,429) % or Mean (SD)</i>	<i>White (n=11,673) % or Mean (SD)</i>	<i>Black (n=1,756) % or Mean (SD)</i>	<i>t /χ^2</i>
<i>Demographics</i>				
Age (in years)	63.87 (9.80)	63.97 (9.55)	62.76 (12.01)	3.46**
Entering cohort				4.91**
50-59	44.80	44.34	49.87	
60-69	30.29	30.25	30.70	
70-79	19.90	20.34	14.93	
80 and older	5.02	5.07	4.51	
Male	47.72	48.03	44.22	5.38*
Living status				149.71***
Living with a spouse	69.60	71.53	48.00	
Living alone	20.84	20.27	27.20	
Living with others	9.56	8.20	24.80	
<i>Chronic disease factors</i>				
Hypertension	42.20	40.88	56.84	134.68***
Diabetes	10.81	10.05	19.24	166.43***
Cancer	10.31	10.56	7.53	7.75**
Lung disease	7.44	7.70	4.60	23.21***
Heart disease	18.13	18.37	15.46	8.31**
Stroke	3.92	3.89	4.32	0.41
Psychiatric or memory	8.95	8.92	9.29	19.71***
Arthritis	45.55	45.58	45.14	0.09
<i>Health behavior factors</i>				
Body Mass Index (BMI)				27.24***
Underweight (≤ 18.5)	1.51	1.52	1.37	
Normal (18.5 - 24.9)	36.20	37.15	25.58	
Overweight (25 - 29.9)	40.75	40.64	41.98	
Obese (≥ 30)	21.54	20.69	31.07	
Drinking				47.57***
None	63.35	61.99	78.50	
Light to moderate	30.99	32.17	17.81	
Heavy	5.67	5.84	3.70	
Smoking	17.49	17.01	22.92	19.35***
Vigorous activity	51.13	51.77	44.05	18.99***
<i>Socioeconomic factors</i>				
Education				76.48***
Less than high school	17.49	15.73	37.06	
High school graduate	37.60	38.14	31.59	
Some college	22.27	22.61	18.47	
Bachelor's or more	22.64	23.52	12.89	
Household income (\$)	60,948 (92,450)	63,288 (92,983)	34,865 (46,143)	13.15***
Total net worth				212.55***
Lowest quintile	18.88	15.54	56.11	
2 nd quintile	20.27	20.16	21.48	
3 rd quintile	20.03	21.72	12.38	
4 th quintile	20.68	21.89	7.16	
Top quintile	20.15	21.70	2.88	

* $p < .05$; ** $p < .01$; *** $p < .001$.

Note: N's are unweighted; percentages and means are weighted. χ^2 based on the design based corrected F statistic, which corrects for the survey design (Rao & Scott, 1984).

white respondents was over \$63,000, compared to less than \$35,000 for black respondents. More than half of the black respondents were in the lowest quintile of net worth compared to 16% of white respondents.

Table 2 presents the median survivor function by the each baseline (wave 4) characteristic. The median survival age can be interpreted as the age it takes for 50% of the respondents to become disabled. Across the 12 disability indicators, the median survival ages ranged from 83 (using a map) to 95 (eating). The median survival ages were similar for both men and women except for using a map, which was 13 years higher for men, and difficulty with toileting, which was 5 years higher for women. For all 12 disability indicators, the respondents living with a spouse had the highest median survival ages, followed by those living with others. Respondents living alone had the lowest median survival ages, indicating the earliest development of disability. Median survival ages were higher for respondents who did not have a disease than the respondents who did. The difference was greater for stroke, psychiatric or memory-related disease, and arthritis. For example, for respondents with a psychiatric or memory-related disease, the median survival age for using a map was 72 years, compared to 85 years among respondents who did not have a psychiatric or memory-related disease. Respondents who reported engaging in vigorous activity and non-smoking behavior had higher median survival ages for all disability indicators. Respondents who were overweight had the highest median survival ages for most disability outcomes except walking and bathing. Interestingly, heavy drinkers had the highest median survival ages, while non-drinkers had the lowest median survival ages for most disability outcomes.

In general, respondents with higher SES had higher survival ages in each disability category than respondents with lower SES. For example, respondents with less than a high

Table 2

Median Survival Age for Each Disability Indicator

Variables	<i>ADLs</i>						<i>IADLs</i>					
	Walk	Dress	Bathe	Eat	Bed	Toilet	Map	Phone	Money	Meds	Shop	Meals
All	87	86	89	95	92	91	83	92	89	93	87	89
Men	88	86	90	97	93	89	90	92	89	95	89	92
Women	86	87	88	94	91	94	77	92	89	92	86	89
Living/spouse	88	87	90	96	93	93	85	93	90	93	88	91
Living alone	83	82	85	93	89	89	78	91	87	92	83	87
Living/others	86	87	88	94	91	90	80	92	88	93	86	89
Disease												
Hypertension	85	85	87	94	90	90	82	92	90	92	85	88
No	89	87	90	95	93	92	85	92	88	94	88	91
Diabetes	78	74	82	93	85	85	78	89	86	89	79	85
No	88	87	90	95	93	92	84	92	89	93	88	90
Cancer	85	85	89	94	92	89	81	93	89	93	86	90
No	87	86	89	95	92	91	84	92	91	93	87	89
Lung disease	81	80	83	94	87	92	78	91	86	94	81	86
No	87	87	89	95	92	85	84	92	89	93	87	90
Heart disease	85	81	87	94	89	88	83	92	89	92	84	88
No	88	87	89	95	92	91	84	92	89	93	87	90
Stroke	76	77	80	87	85	85	70	86	87	86	77	84
No	87	87	89	95	92	91	84	92	89	93	87	90
Memory/Psych.	81	82	84	92	86	86	72	88	84	89	80	85
No	88	87	89	95	93	92	85	92	90	93	87	90
Arthritis	84	82	88	95	89	89	82	91	89	93	85	89
No	90	90	90	95	93	93	85	92	89	93	88	90
Health behaviors												
Underweight	84	79	87	94	88	88	84	92	89	94	84	88
Normal weight	89	88	90	94	92	92	82	91	90	92	87	89
Overweight	87	88	89	95	93	93	85	92	90	94	88	91
Obese	85	88	87	91	89	90	76	89	87	88	82	88
Non-drinker	85	85	88	94	90	90	81	91	88	92	85	88
Moderate	85	81	87	92	--	91	88	89	92	94	89	91
Heavy drinker	92	89	92	---	94	94	89	94	92	96	91	93
Smoking	80	83	84	90	87	--	77	90	87	89	82	86
No	88	87	89	95	92	91	84	92	89	93	87	90
Vigorous	91	89	92	96	93	93	85	92	91	94	90	92
No	84	84	87	94	90	89	82	92	88	92	85	88
SES												
< High school	79	81	86	95	88	89	70	89	86	92	82	87
High school	91	89	91	98	93	93	91	94	90	94	89	91
Some college	88	87	90	94	93	91	85	92	91	93	88	91
Bachelor's +	87	86	89	94	92	91	83	92	89	93	87	89
Low income	83	83	87	93	89	89	75	91	87	92	84	88
Middle income	88	87	89	95	93	93	85	92	89	93	88	91
High income	91	87	94	---	95	93	92	95	93	95	91	92
Lowest quintile	80	79	84	93	86	86	75	89	84	91	80	86
2 nd quintile	81	88	91	97	92	91	88	92	90	95	89	92
3 rd quintile	88	88	93	95	95	92	86	92	91	93	88	90
4 th quintile	88	88	90	94	92	93	85	95	93	94	89	90
Highest quintile	87	87	89	93	93	92	84	92	90	93	88	89

Note: Ages were obtained from the Kaplan–Meier product-limit estimates. Income was categorized by applying sampling weights; categories were low (<\$27,005), middle (\$27,005 - \$58,180), and high (>\$58,180).

school diploma had the lowest median survival ages in each disability category, while respondents with a high school diploma (but no college) had the highest median survival ages. Respondents in the higher income group had the highest median survival ages for all disability indicators. The median survival ages were lowest for the respondents in the lowest net worth quintile. However, there were no noticeable differences in median survival age among respondents in the other four quintiles of net worth.

Bivariate Relationship between Race and Disability

Survivor function and the incidence rate. Table 3 shows the differences between blacks and whites in the median survivor function, the 25th percentile of survivor function, and the disability incidence rate. Whites had higher median survival ages than blacks, with differences ranging from 2 years (eating and taking medications) to 11 years (using a map). In the 25th percentile of survivor function, the differences between the two groups were narrower except in using a map, and survivor functions between the two groups were statistically different for all disability indicators.

In disability research, the incidence rate is the ratio of the number of respondents that become disabled and the sum of the length of time each respondent was exposed to a given risk. It can be viewed as the speed at which disability onset occurs after risk exposure. For all disability indicators, the incidence rate of black respondents was higher than that for whites. The greatest differences were in using a map, while the smallest differences were in taking medications.

It is interesting that survival ages for using a map were noticeably lower than for all other disability indicators. For example, among black respondents, the median survival age for using a map was 74 years; for the other disability indicators it was 80 or older.

Table 3

Disability Survival Ages and Incidence Rates by Race

Disability Indicators	50%		25%		Incidence Rate			Test of Equality ^{a)}	
	White	Black	White	Black	All	White	Black	χ^2	Wald χ^2
<i>ADL indicators</i>									
Walking across a room	87	82	93	90	.016	.015	.022	43.44***	42.33***
Dressing	87	80	94	90	.019	.018	.027	46.44***	42.87***
Bathing	89	84	94	93	.014	.013	.020	43.89***	49.17***
Eating	95	93	102	---	.006	.006	.009	33.13***	28.69***
Getting in/out of bed	92	86	99	98	.011	.011	.017	35.53***	33.19***
Toileting	92	86	99	98	.012	.011	.017	32.17***	36.45***
<i>IADL indicators</i>									
Using a map	85	74	95	85	.023	.021	.038	140.04***	90.04***
Making a telephone call	92	89	97	97	.009	.009	.012	14.85***	18.56***
Managing money	89	84	95	91	.013	.012	.019	63.71***	58.77***
Taking medications	93	91	--	---	.008	.008	.010	16.13***	10.64**
Shopping for groceries	87	81	93	90	.017	.017	.024	42.84***	49.88***
Preparing hot meals	90	85	95	94	.012	.012	.017	29.35***	37.33***

** $p < .01$; *** $p < .001$.

Note: ^{a)} χ^2 is based on stratified log rank tests with an unweighted sample; Wald χ^2 is based on Cox models with a weighted sample.

Survival and Hazard Curves. The survivor functions of black and white respondents are graphically presented in Figure 3. The survivor curves show that for both races, as age increased, rates of non-disability steadily decreased. In general, the survivor functions among white respondents decreased in a swollen curve, but the survivor functions among black respondents decreased in a relatively straight line.

Across all disability indicators, survivor functions of white respondents were higher than those of black respondents for most of the study window. In general, the differences in survivor functions between the two groups became larger until around age 80; thereafter, the gap started to decrease. For most disability indicators, except using a toilet, using a map, and

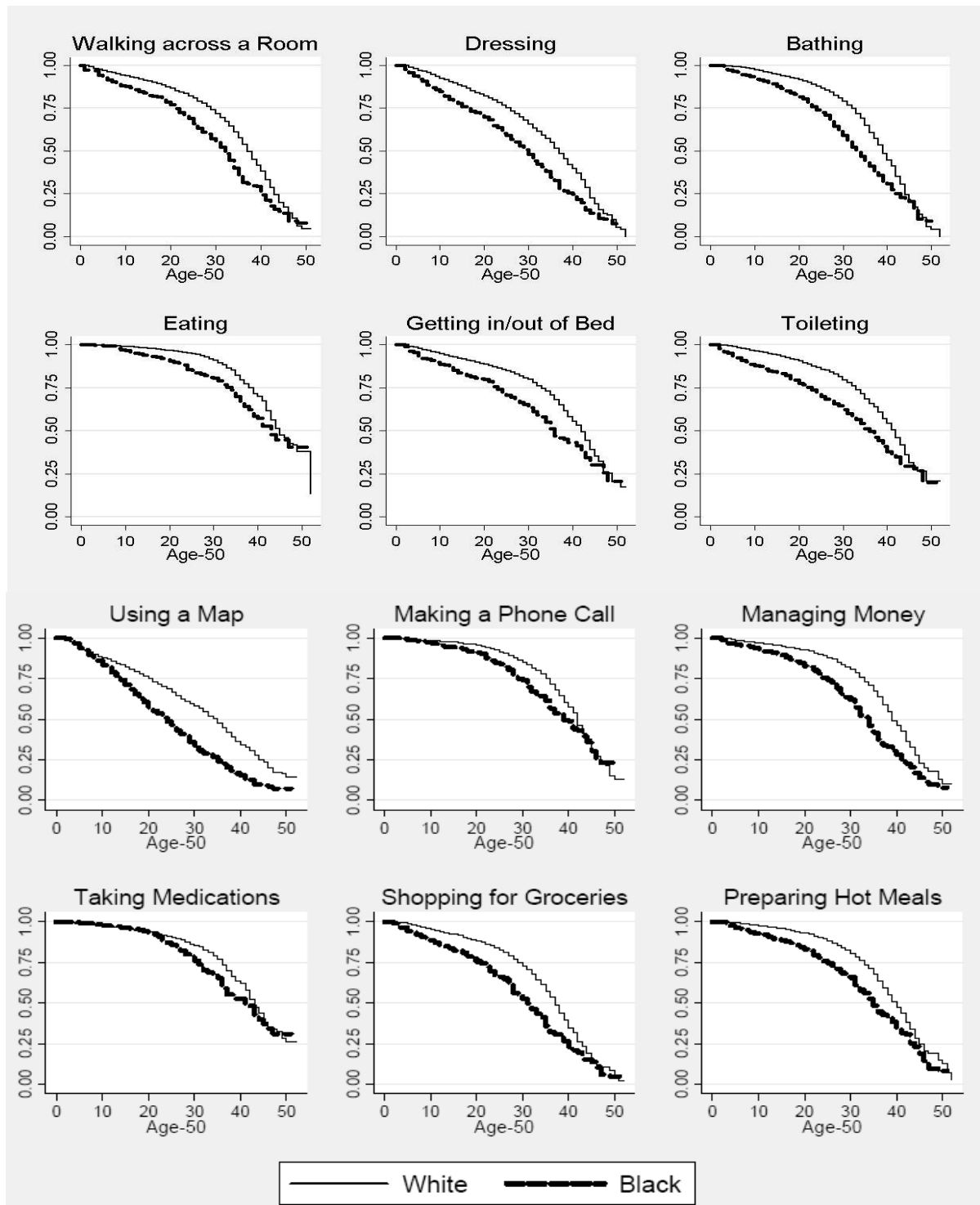
managing money, the survivor functions of the two groups crossed at the end stage of the study window.

These findings indicate that older white respondents initially had a lower risk of becoming disabled, but they experienced an increase in risk starting around age 80. After age 80 or so, the rate of disability onset among white respondents accelerated faster than that of black respondents, which resulted in the convergence of blacks' and whites' survivor functions at the oldest ages (around the mid-90s). This crossover phenomenon is more obviously noticeable in the hazard curves presented in Figure 4.

Figure 4 presents the hazard plots for each disability indicator for black and white respondents. With age as time scale, the hazard function, also called the hazard curve, depicts the risk of disability as a continuous function of age. It can be seen as the risk of becoming disabled at a certain age. The hazard curves showed an opposite trend than the survival curves presented in Figure 3. Hazard functions for both black and white respondents gradually increased until around age 90 (the specific age varies by each disability indicator). At the very end of the study window, the hazard functions generally decreased for both groups. The crossover phenomenon of the hazard functions was apparent for most of the disability indicators except using a map. Age 85 was the crossover age for most of the disability indicators. Before reaching their mid-80s, black respondents had a greater risk of a disability. Thereafter, white respondents became more vulnerable to becoming disabled. The only disability indicator with a different crossover age was managing money, for which the crossover age was in the early 90s. Unlike for other disability indicators, the hazard curves for using a map did not present a crossover phenomenon, which indicates that black

Figure 3

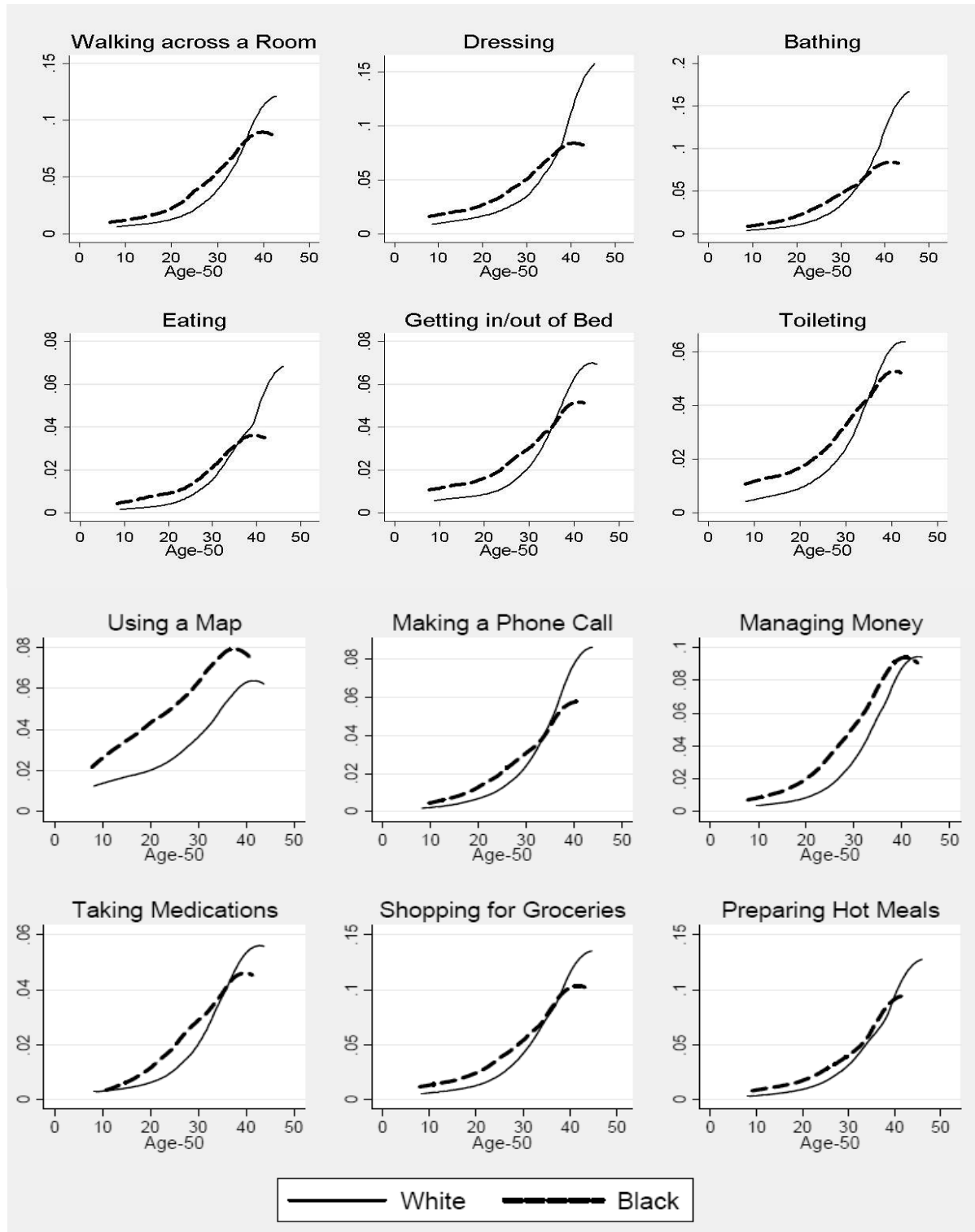
Survival Curves for Black and White Respondents: Survivor Function by Age



Note: To calculate age, add 50 to the value on the X axis. For example, 0 indicates age 50; 10 indicates age 60, etc.

Figure 4

Smooth Hazard Curves for Black and White Respondents: Hazard Function by Age



Note: To calculate age, add 50 to the value on the X axis. For example, 0 indicates age 50; 10 indicates age 60, etc.

respondents consistently had a greater risk of having difficulty using a map until the last stage of life.

In sum, the survivor functions between the two groups were significantly different. On average, black respondents were at higher risk of becoming disabled according to all disability indicators, as seen in Table 3. However, both the survival and the hazard curves show that the black/white gap in the risk of becoming disabled was heavily dependent on age. In general, the risk of becoming disabled was higher for black respondents until about age 85. Thereafter, white respondents became more at risk for becoming disabled. Most disability indicators presented a similar trend, but using a map was noticeably different from the other indicators.

Mediation Analysis

To evaluate the mediating roles of disease, health behaviors, and SES on the causal relationship between race and disability, a series of Cox regressions was conducted. Six Cox regressions were conducted for each of the 12 disability indicators, resulting in a total of 72 Cox regressions based on the survey-based analysis.¹⁹ The results are presented by grouping ADL and IADL indicators separately.

ADL indicators. Table 4 reports the summary of the six Cox regression models for each of six ADL indicators. Unadjusted models in Table 4 show Cox regressions using race (black) as the only predictor. Model 1 includes three demographic covariates (entering cohort, gender, and living status) as well as race (black). These demographic covariates were applied as controllers in each of the other models (Models 2-5). Models 2, 3, and 4 each added one of the three mediating factors (disease, health behaviors, and SES), respectively. Model 5 (full

¹⁹ This study also conducted another 72 Cox regressions based on the LWA model, and presented in Appendix C.

model) included all covariates.

To quantify the role of each mediating factor in narrowing the black/white disability gap, the percentage change of the hazard of becoming disabled was calculated by comparing the hazard ratio for blacks in Model 1 to that in models 2, 3, and 4 respectively.²⁰ The change in the black hazard ratio when all three factors were added is reported in Model 5. For example, for the ADL disability indicator walking, the hazard ratio obtained in Model 1 was 1.578. By adding the disease factor (Model 2), the hazard ratio was decreased to 1.427, narrowing the black/white gap by 26.1%. Despite this narrowing, however, the gap was still significant ($p < .001$). When all three factors were added to Model 1 (Model 5), the black/white gap of disability indicated by walking decreased by 90.8%, and the gap was no longer significant.

For all 6 ADL indicators, unadjusted models showed that black respondents are significantly more at risk of becoming disabled than white respondents, as already noted in the previous section about the bivariate relationship between race and disability. Hazard ratios for blacks ranged from 1.595 (walking) to 1.850 (eating); that is, the hazards of experiencing difficulty walking across a room, and difficulty with eating were 1.595 and 1.850 times greater for black respondents than for white respondents, respectively.

When controlling for demographics (i.e., entering cohort, gender, and living status) (Model 1), hazard ratios for blacks ranged from 1.427 (walking) to 1.784 (eating). The black/white disability gap was highly significant ($p < .001$) for all 6 ADL disability indicators. In Model 2, which included the eight chronic disease variables in addition to the demographic variables, the hazard ratios ranged from 1.427 (walking) to 1.78 (eating), which

²⁰ % change = (the Black H.R. in model 1 – the Black H.R. in each subsequent model) / (1 – Black H. R. in model 1) * 100.

Table 4

Changes in the Hazard Ratios for Blacks for ADL Disability Indicators

ADL indicators	Unadjusted	Model 1	Model 2	Model 3	Model 4	Model 5
<i>Walking across a room</i>						
H.R	1.595***	1.578***	1.427***	1.281**	1.102	1.053
% change	---	---	-26.12%	-51.38%	-82.35%	-90.83%
S.E	0.135	0.136	0.123	0.113	0.117	0.105
<i>Dressing</i>						
H.R	1.618***	1.631***	1.532***	1.425***	1.242**	1.228*
% change	---	---	-15.69%	-32.65%	-61.65%	-63.87%
S.E	0.099	0.098	0.098	0.088	0.094	0.095
<i>Bathing</i>						
H.R	1.710***	1.700***	1.564***	1.436***	1.196	1.172
% change	---	---	-19.43%	-37.71%	-72.00%	-75.43%
S.E	0.150	0.153	0.139	0.130	0.111	0.104
<i>Eating</i>						
H.R	1.850***	1.843***	1.784***	1.661***	1.455**	1.496**
% change	---	---	-7.00%	-21.59%	-46.03%	-41.16%
S.E	0.249	0.249	0.253	0.232	0.197	0.213
<i>Getting in out bed</i>						
H.R	1.660***	1.651***	1.531***	1.435**	1.183	1.170
% change	---	---	-18.43%	-33.18%	-71.89%	-73.89%
S.E	0.169	0.168	0.156	0.157	0.134	0.128
<i>Toileting</i>						
H.R	1.700***	1.678***	1.562***	1.438***	1.323**	1.286*
% change	---	---	-17.11%	-35.40%	-52.36%	-57.82%
S.E	0.131	0.128	0.124	0.115	0.125	0.124

* $p < .05$; ** $p < .01$; *** $p < .001$.

Note: The unadjusted model includes race only. Model 1 includes race and demographics (entering cohort, gender, and living status). Model 2 includes diseases and demographics. Model 3 includes health behaviors and demographics. Model 4 includes SES and demographics. Model 5 includes diseases, health behaviors, SES, and demographics.

means that blacks were 43% to 78% more likely to experience disability, depending on

which indicator is used. While these hazard ratios were still highly significant ($p < .001$), the

disability gap in Model 2 decreased by 7.00% (eating) to 26.12% (walking) when compared with Model 1.

When health behavior factors (BMI, alcohol consumption, smoking, and vigorous activity) and demographic variables were included (Model 3), the black/white gap of ADL disability decreased for all 6 ADL indicators. Hazard ratios for blacks in Model 3 ranged from 1.281 (walking) to 1.661 (eating), meaning that the black/white gap was still highly significant for all of the ADL indicators ($p < .001$). Nonetheless, controlling for health behavior factors decreased the disability gap by anywhere from 22.59% (eating) to 51.38% (walking) when compared to Model 1.

When SES-related variables (education, income, and net worth) and demographic variables were included (Model 4), the black/white disability gap narrowed enormously. Hazard ratios for blacks in Model 4 ranged from 1.102 (walking) and 1.455 (eating), which is equivalent to a decrease in the gap of anywhere from 46.03% (eating) to 82.35% (walking). In fact, the black/white gaps in walking, getting in and out of bed, and bathing became non-significant when SES and demographics were controlled for.

When all three categories of risk factors—disease, health behaviors, and SES—plus demographic variables were included (Model 5), the hazard ratios for black respondents were between 1.05 (walking) and 1.50 times (eating) compared to white respondents. In this model, the black/white disability gap became no longer significant for three out of the six ADL indicators: walking, bathing, and getting in and out of bed. The percentage decrease in the gap ranged from 41.2% (eating) to 90.8% (walking). It is interesting that the decreases in the black/white gap in Model 5 were similar to those in Model 4. This result implies that adding health behaviors and diseases minimally contributed to narrow the gap once SES was

controlled for.

Across the six ADL indicators, the average decrease in the disability gap after controlling for demographics was 17.3% when controlling for the chronic disease factor, 35.3% when controlling for the health behavior factor, 64.4% when controlling for the SES factor, and 67.2% when controlling for all three factors together. Across all ADL indicators, SES was the most influential factor in the black/white disability gap.

IADL indicators. Table 5 summarizes the Cox regressions for each of the six IADL indicators. An unadjusted model shows that the hazard ratio for blacks ranges from 1.430 (taking a medication) to 1.881 (using a map). By controlling for demographics (entering cohort, gender, and living status) (Model 1), hazard ratios changed only minimally from those in the unadjusted model. Hazard ratios ranged from 1.420 (taking a medication) to 1.876 (using a map) in Model 1, and the disability gap remained highly significant ($p < .001$) across all six IADL indicators.

When chronic disease variables were added to Model 1 (Model 2), the black/white disability gap dropped for all IADL indicators, which decreases ranging from 0.12% (using a map) to 18.81% (taking a medication). Hazard ratios for blacks ranged from 1.341 (taking a medication) to 1.841 (managing money), and all were highly significant ($p < .001$). Model 3 included health behaviors in addition to demographics. In that model, hazard ratios for blacks were between 1.281 (taking a medication) and 1.737 (using a map), and the disability gap narrowed by 12.47% (using a map) to 42.38% (shopping for groceries). The gap was still significant for all six IADL indicators.

As with the ADL indicators, including SES in addition to demographics (Model 4) substantially decreased the black/white disability gap for IADL indicators. Hazard ratios for

Table 5

Changes in the Hazard Ratios for Blacks for IADL Disability Indicators

IADL indicators	Unadjusted	Model 1	Model 2	Model 3	Model 4	Model 5
<i>Using a map</i>						
H.R	1.881***	1.842***	1.841***	1.737***	1.418***	1.497***
% change	---	---	-0.12%	-12.47%	-50.36%	-40.97%
S.E	0.152	0.153	0.154	0.146	0.118	0.121
<i>Making a phone call</i>						
H.R	1.559***	1.573***	1.567***	1.451**	1.125	1.167
% change	---	---	-1.05%	-21.29%	-78.18%	-70.86%
S.E	0.189	0.189	0.185	0.175	0.147	0.149
<i>Managing money</i>						
H.R	1.880***	1.876***	1.824***	1.695***	1.258*	1.279**
% change	---	---	-5.94%	-20.66%	-70.55%	-68.15%
S.E	0.162	0.165	0.148	0.152	0.121	0.115
<i>Taking a medication</i>						
H.R	1.430***	1.420***	1.341**	1.281*	1.047	1.054
% change	---	---	-18.81%	-33.10%	-88.81%	-87.14%
S.E	0.141	0.141	0.135	0.125	0.120	0.108
<i>Shopping for groceries</i>						
H.R	1.643***	1.630***	1.521***	1.363***	1.143	1.129
% change	---	---	-17.30%	-42.38%	-77.30%	-79.52%
S.E	0.128	0.133	0.117	0.120	0.098	0.094
<i>Preparing hot meals</i>						
H.R	1.679***	1.663***	1.584***	1.479***	1.256*	1.269**
% change	---	---	-11.92%	-27.75%	-61.39%	-59.43%
S.E	0.133	0.139	0.132	0.124	0.109	0.110

* $p < .05$; ** $p < .01$; *** $p < .001$

Note: The unadjusted model uses race as the only predictor. Model 1 includes race and demographics (entering cohort, gender, and living status). Model 2 includes diseases and demographics. Model 3 includes health behaviors and demographics. Model 4 includes SES and demographics. Model 5 includes diseases, health behaviors, SES, and demographics.

black respondents were between 1.05 (taking a medication) and 1.42 (using a map), and the disability gap narrowed by 50.36% (using a map) to 88.81% (taking a medication). With

these decreases, the disability gap became non-significant for three IADL indicators: making a phone call, taking a medication, and shopping for groceries. When including all three categories of risk factors—disease, health behaviors, and SES—as well as demographics (Model 5), the hazard ratio ranged from 1.054 (taking a medication) to 1.497 (using a map), and the decrease in the disability gap ranged from 40.97% (using a map) to 87.14% (taking a medication). These decreases are similar to those seen in Model 4, and like in Model 4, the black/white disability gap became no longer significant for three IADL indicators: making a phone call, taking medication, and shopping for groceries. However, black respondents still had a significantly higher risk for experiencing difficulty with using a map, managing money, and preparing hot meals. Across the six IADL indicators, the average decrease in the black/white disability gap after controlling for demographics was 9.2% when controlling for chronic disease, 26.3% when controlling for health behaviors, 71.1% when controlling for SES, and 67.7% when controlling for all three factors. SES was most influential factor in the gap for IADL disability. In general, the decrease in the black/white disability gap caused by controlling for chronic disease was greater for IADL indicators than for ADL indicators, and controlling for SES narrowed the gap further for IADL indicators than for ADL indicators.

Across all 12 ADL and IADL indicators, controlling for chronic disease narrowed the black/white disability gap by 13.24%, controlling for health behaviors decreased the gap by 30.80%, and controlling for SES narrowed the gap substantially—by 67.74%. Controlling for all three factors decreased the gap by 71.17%. The mediating role of the SES factor was most apparent for the indicator of taking a medication; the disability gap for this indicator decreased by 92.8% when controlled for SES. It is important to note that across all 12 disability indicators, SES was the leading contributor to the black/white disability gap, and

chronic disease had the least influence. Across all disability outcomes, all three factors contributed to narrowing the gap. Also, the Likelihood Ratio (LR) tests in Appendix D showed that all three factors significantly improved model fits.²¹

Full Model

As explained earlier, the full model (i.e., Model 5) included all covariates to predict the timing of disability onset. Beyond the two research questions of this dissertation (Does a black/white disability gap exist among older adults, and does it change with age? If so, to what extent do SES, disease, and health behaviors contribute to this gap?), which were answered in previous sections, the full model provides very useful information regarding the influence of each variable on the timing of onset of each ADL and IADL disability among blacks and whites ages 50 and older. The model-predicted survivor and hazard curves based on the full model are also provided in this section.

Predictors of ADL/IADL disability onset. Table 6 provides information on the effects of each covariate on the timing of ADL disability onset. Black respondents had a significantly higher risk of disability onset according to two indicators: dressing ($p < .05$) and toileting ($p < .01$) compared to white respondents when all other variables were held constant. The hazard for older entering cohorts of becoming disabled was smaller for all ADL disability indicators. Living status significantly affected disability onset according to only one ADL indicator, toileting; for that indicator, respondents living with others had a higher risk than respondents living with a spouse. Men had a higher risk of experiencing difficulty with dressing ($p < .001$) and a smaller risk of difficulty with toileting ($p < .001$) when

²¹ The LR test is used to compare the fit between two models, one of which is nested within the other. LR tests do not prove whether the changes in HRs for blacks are significant from Model 1 to each subsequent model. Rather, the tests show that inclusion of each factor significantly improves model fit. That is, the tests are related to outcome (timing of a disability onset) rather than the HR for blacks.

Table 6

Hazard Ratios for ADL Disability Indicators

Variables	Walking across a room	Dressing	Bathing	Eating	Getting in/out of Bed	Toileting
Entering cohort (Ages 50-59)						
Ages 60-69	0.812	0.581***	0.622**	0.775	0.664*	0.583***
Ages 70-79	0.578**	0.400***	0.392***	0.382**	0.325***	0.347***
Age 80 and over	0.495***	0.308***	0.252***	0.246***	0.194***	0.209***
Male	0.974	1.326***	0.914	1.010	1.034	0.701***
Living status (Living with						
Living with others	1.083	1.091	1.132	1.236	1.139	1.265*
Living alone	0.988	0.940	1.000	1.204	1.090	1.147
Diseases						
Hypertension	1.157*	1.036	1.187**	1.058	1.129	1.060
Diabetes	1.752***	1.504***	1.675***	1.451**	1.506***	1.489***
Cancer	1.177*	1.009	1.049	1.154	1.090	1.242**
Lung disease	1.300*	1.300**	1.522***	1.119	1.205	1.057
Heart disease	1.110	1.100	1.090	1.087	1.123	1.187*
Stroke	1.611***	1.510***	1.512***	1.620***	1.500**	1.367*
Psychiatric/memory	1.374***	1.333***	1.526***	1.545***	1.477***	1.534***
Arthritis	1.547***	1.615***	1.227**	1.172	1.507***	1.571***
Health behaviors						
Body Mass Index (Normal)						
Underweight	1.150	0.950	1.251	1.290	1.140	1.183
Overweight	1.090	0.988	1.025	0.825*	0.887	0.981
Obese	1.314***	1.634***	1.323***	0.922	1.188	1.379***
Drinking (None)						
Light to moderate	0.603***	0.870*	0.723***	0.697***	0.782**	0.685***
Heavy	0.880	1.092	1.064	0.922	0.867	1.150
Smoking	1.805***	1.291**	1.673***	1.555**	1.440**	1.115
Vigorous activity	0.602***	0.800***	0.692***	0.735**	0.741***	0.734***
Socioeconomic status						
Education (< High school)						
High school	0.861*	0.969	0.940	0.989	0.932	0.999
Some college	0.850	0.940	0.942	1.062	0.802*	1.054
Bachelor's or more	0.797*	0.978	1.005	0.943	0.890	1.016
Household income	0.955	0.951	0.939*	0.913	0.924*	1.004
Total net worth (Lowest quintile)						
2 nd quintile	0.892	0.781***	0.901	0.982	0.826*	0.759**
3 rd quintile	0.848	0.782**	0.819*	1.091	0.858	0.883
4 th quintile	0.810	0.803**	0.788**	0.905	0.787*	0.777
Top quintile	0.834	0.823	0.659***	0.881	0.810	0.891

* $p < .05$; ** $p < .01$; *** $p < .001$.

compared to women.

Among the eight disease variables, diabetes, stroke, and psychiatric or memory problems were significantly positive predictors for all ADL disability indicators. Arthritis was also positively related to onset of all ADL disabilities except eating. However, hypertension, cancer, and heart disease each were found to be a significant predictor for only one or two ADL indicators. For example, respondents with hypertension were 15.7% faster to experience difficulty with walking across a room ($p < .05$) and 18.7% faster to have difficulty with bathing ($p < .01$) compared to those without hypertension.

All health behavior variables were significantly related to most ADL indicators. Respondents with obesity were at more risk to develop difficulty with walking across a room, dressing, bathing, and toileting. Across all ADL indicators, light to moderate alcohol drinkers were at significantly less risk to become disabled compared to respondents who did not drink alcohol. Smokers had a higher hazard to become disabled according to all ADL indicators except toileting. Also, respondents who reported engaging in vigorous activity had a significantly lower risk to become disabled compared to the respondents who did not.

Unlike for disease- and health behaviors-related factors, the effect of SES on the timing of ADL disability onset varied for each SES-related variable. Education was significantly associated with higher risk of difficulty walking across a room and toileting. Respondents with higher household income had a lower risk of experiencing difficulty with bathing and getting in and out of bed. Total net worth was a significant predictor for all ADL indicators except two: difficulty with walking across a room and eating.

Table 7 presents the findings of the full model regarding each IADL indicator. Living status did not affect the timing of onset for any IADL indicator. Men had a lower risk of

experiencing difficulty with using a map ($p < .001$), shopping for groceries ($p < .001$), and preparing hot meals ($p < .001$) but were at higher risk for difficulty with making a phone call ($p < .001$). Regarding disease-related variables, diabetes, stroke, and psychiatric or memory problems were significantly positive predictors for all IADL disability indicators.

Hypertension was also positively related to disability onset for all IADL indicators except making a phone call. Arthritis was found to be a significant predictor for IADL disability in shopping for groceries ($p < .001$) and preparing hot meals ($p < .001$). Lung disease and heart disease were significantly predictors only for disability in shopping for groceries.

Interestingly, cancer was not significantly related to any of IADL disability indicators.

Compared to respondents with normal weight, respondents with obesity had a higher risk of IADL disability in shopping for groceries ($p < .01$), but a lower risk of disability in using a map ($p < .001$), making a phone call ($p < .05$), managing money ($p < .05$), and taking medication ($p < .01$). Light and moderate drinkers had a lower risk of disability for all IADL indicators compared to respondents who did not drink alcohol. Respondents who engaged in vigorous activity were at lower risk of disability for all IADL indicators except difficulty with using a map. Smokers had a higher risk of disability for all IADL indicators except difficulty with making a phone call. In general, respondents with higher SES had a lower risk of experiencing IADL disabilities. However, the effect of each SES variable differed according to IADL component. For example, education was a significant predictor of all IADL disabilities except difficulty with taking a medication. Net worth was significantly associated with most IADL disabilities except difficulty with using a map. However, income was not a significant determinant of any of the IADL disabilities.

Table 7

Hazard Ratios for IADL Disability Indicators

Variables	Using a map	Making a telephone call	Managing money	Taking a medication	Shopping for groceries	Preparing hot meals
Black	1.497***	1.167	1.279***	1.054	1.129	1.269**
Entering cohort (Ages 50-59)						
Ages 60-69	0.876	0.715	0.773	0.631	0.650**	0.593**
Ages 70-79	0.857	0.514*	0.373***	0.250***	0.363***	0.260***
Age 80 and over	0.576***	0.366***	0.245***	0.161***	0.234***	0.169***
Male	0.517***	1.632***	1.122*	1.115	0.785***	0.877
Living status (Living with spouse)						
Living with others	0.958	1.102	1.181	0.897	1.061	1.102
Living alone	0.978	0.982	1.014	0.951	0.974	0.878
Diseases						
Hypertension	1.122*	1.015	1.143*	1.182*	1.192***	1.176**
Diabetes	1.133*	1.260**	1.353***	1.469***	1.593***	1.466***
Cancer	1.089	0.872	0.886	0.872	1.034	0.996
Lung disease	1.079	1.051	1.012	0.960	1.480***	1.201
Heart disease	0.965	1.014	1.009	1.106	1.245***	1.071
Stroke	1.491***	1.525***	1.537***	1.637***	1.587***	1.583***
Psychiatric/memory	1.608***	1.574***	1.854***	1.696***	1.518***	1.574***
Arthritis	1.005	0.937	0.949	1.075	1.248***	1.149**
Health behaviors						
Body Mass Index (Normal)						
Underweight	1.102	1.301	1.244	1.360	1.178	1.126
Overweight	0.878**	0.893	0.923	0.766**	0.904	0.860*
Obese	0.795***	0.777*	0.820*	0.738**	1.202**	0.948
Drinking (None)						
Light to moderate	0.768***	0.651***	0.684***	0.548***	0.620***	0.673***
Heavy	0.945	1.162	0.918	1.052	0.881	0.957
Smoking	1.213*	1.183	1.438***	1.428**	1.760***	1.532***
Vigorous activity	0.983	0.872*	0.808**	0.782**	0.683***	0.760***
Socioeconomic status						
Education (< High school)						
High school	0.693***	0.794*	0.837*	0.937	0.808**	0.944
Some college	0.550***	0.740**	0.783**	0.976	0.811**	0.801*
Bachelor's or more	0.401***	0.638***	0.836*	0.869	0.816**	0.866
Household income (log)	1.008	0.959	0.991	1.035	0.987	0.971
Total net worth (Lowest quintile)						
2 nd quintile	0.969	0.875	0.725***	0.719***	0.807***	0.895
3 rd quintile	0.962	0.819	0.647***	0.723**	0.814**	0.849
4 th quintile	0.913	0.754*	0.590***	0.634***	0.764**	0.804*
Top quintile	0.892	0.770*	0.518***	0.709*	0.778*	0.820

* $p < .05$; ** $p < .01$; *** $p < .001$.

In sum, all disease-related and health behavior-related variables were similar predictors of ADL/IADL disability. However, the effect of each SES-related variable varied greatly depending on which ADL/IADL indicator was being used. For example, education was the only SES-related variable significantly associated with difficulty with using a map, and net worth was the only SES variable significantly associated with difficulty with taking a medication, dressing, and toileting. Interestingly, income was a significant predictor for only two indicators, bathing and getting in/out of bed. However, net worth was found to be an important determinant for most disability indicators except difficulty with walking across a room, eating, and using a map. No SES-related variables predicted the timing of onset of difficulty with eating.

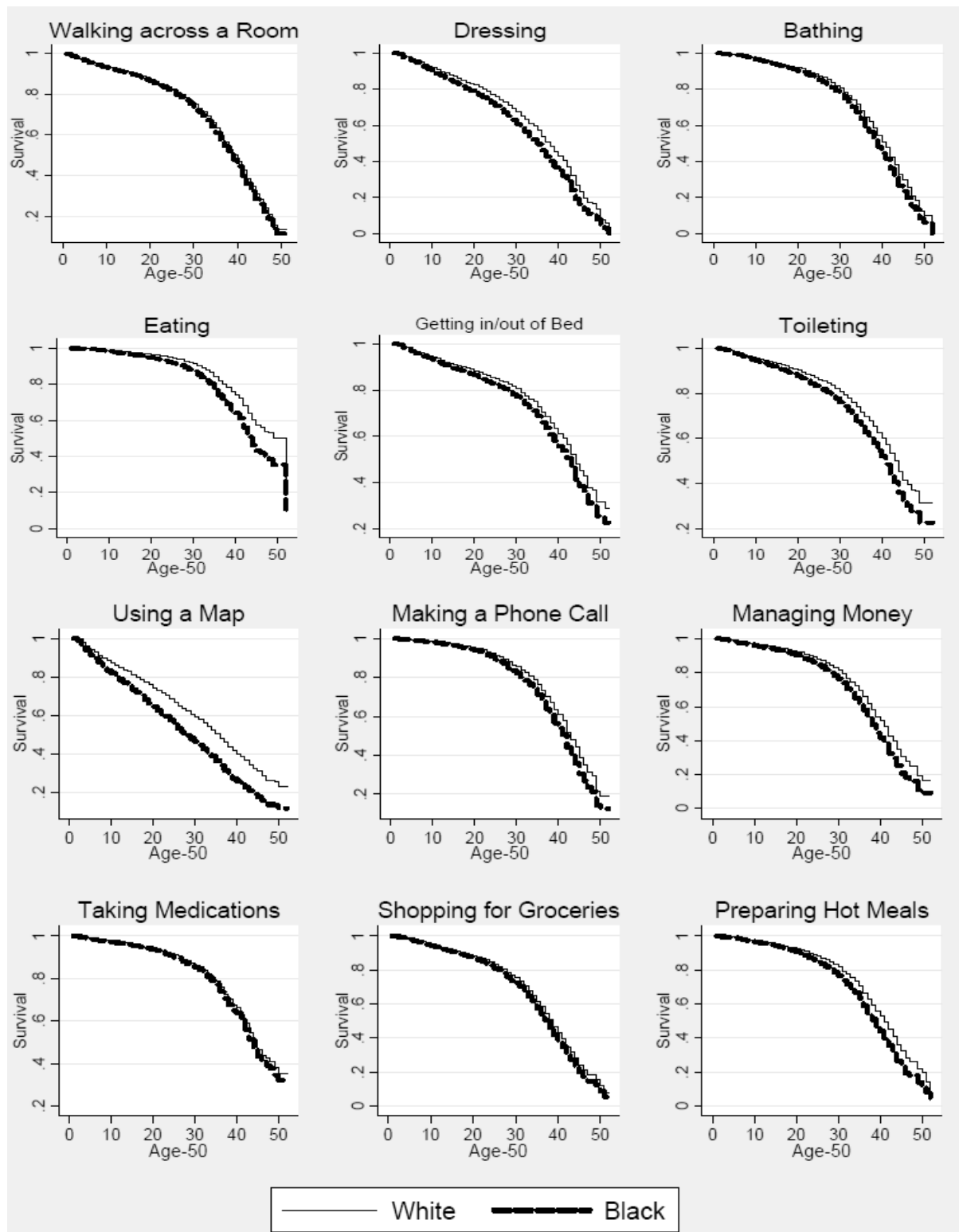
Model-predicted survival and hazard curves. The black/white disability gap model-predicted survivor curves were generated based on the full model to demonstrate graphically the relative risk of becoming disabled. Using parameter estimates from Model 5 for black respondents while controlling for all other covariates at their mean, survivor curves for black and white respondents are shown in Figure 5.

As seen in Figure 5, the black/white disability gap for two survivor functions was mostly removed for most disability indicators. Two survivor functions also had very similar shapes. Compared to Figure 3, which included race as the only predictor, Figure 5 shows that the difference of survivor functions between the two groups became minimal except in difficulty with eating and using a map. As found previously, black respondents had a significantly higher risk than white respondents for disability according to these two indicators ($p < .001$) even after controlling for all covariates.

The decrease in the black/white disability gap brought about by the three mediating

Figure 5

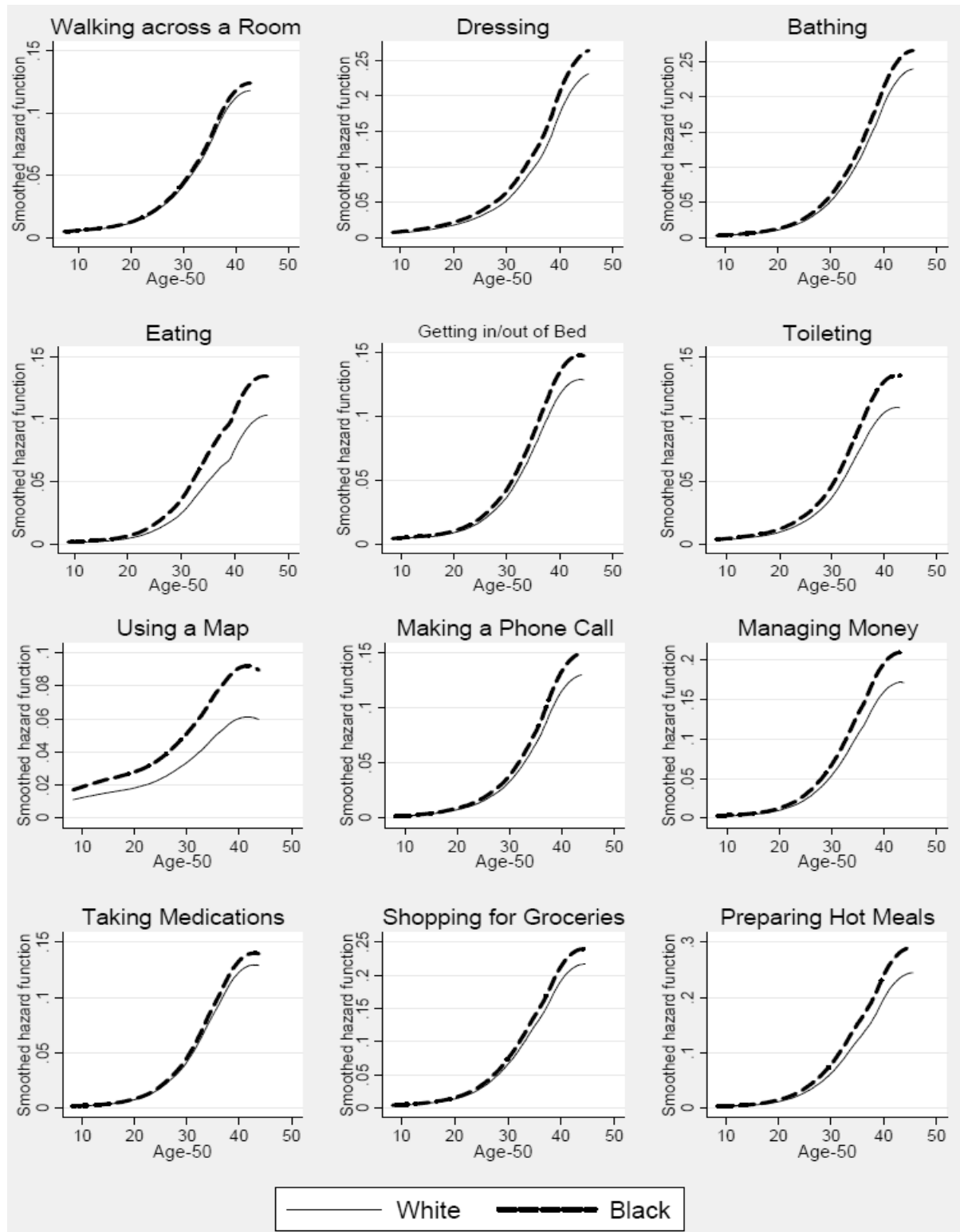
Model-Predicted Survival Curves for Black and White Respondents: Survivor Function by Age



Note: To calculate age, add 50 to the value on the X axis. For example, 0 indicates age 50; 10 indicates age 60, etc.

Figure 6

Model Predicted Hazard Curves for Black and White Respondents: Hazard Function by Age



Note: To calculate age, add 50 to the value on the X axis. For example, 0 indicates age 50; 10 indicates age 60, etc.

factors (i.e., diseases, health behaviors, and SES) was more apparent in the model-predicted hazard curves than the model-predicted survival curves. Figure 6 shows model-predicted hazard curves based on the full model. Compared with the hazard curves that do not control for any covariates (Figure 4), hazard curves for whites and blacks in Figure 6 became very similar. Noticeably, there was no longer any crossover for any of the disability indicators. Hazard curves for black respondents were located below those for white respondents throughout the study window, but the gap between black and white respondents was minimal for most disability indicators. The shapes of the curves for black and white respondents became parallel. For both groups, hazard functions steadily increased until respondents were in their early or mid-70s; thereafter, the curves started to increase rapidly until almost the end of the study window. Similarities in the model-predicted survival and hazard curves between the two races imply that the black/white disability gap is mostly influenced by added covariates (i.e., variables related to disease, health behaviors, and SES).

CHAPTER 6

DISCUSSION AND CONCLUSION

This dissertation study examined the black/white differences in the onset of disability as defined by difficulty with ADLs and/or IADLs. Six ADL indicators and six IADL indicators were used to measure disability, and separate analyses were conducted for each indicator to investigate the risk of disability onset. The sample was restricted to non-Hispanic black and white adults ages 50 and older who did not have any ADL/IADL disabilities at the study baseline (1998). Each ADL/IADL indicator was measured every two years until 2008. Specifically this study asked two research questions: 1) Is there a difference between blacks and whites in the risk of disability onset, and does it change with advancing age? 2) If yes, to what extent do chronic disease, health behaviors, and socioeconomic status contribute to explaining this black/white disability gap?

While the black/white disability gap among older adults has been explored in many previous studies, the findings were inconsistent because of differences in data, sampling, methods, and measures of disability employed by researchers. To overcome the limitations of previous studies, this dissertation study used 11 years of longitudinal data from a nationally representative sample to produce more accurate and generalizable outcomes. This study makes a contribution to expanding the research literature in two important ways: 1) It investigated each indicator of ADL/IADL disability separately; and 2) unlike most previous studies, this study included an expanded age range that included persons ages 50 years and older.

This study explored two important topics simultaneously. First, it examined the age-specific black/white disability gap. Second, it investigated the mediating roles of disease, health behaviors, and SES in the black/white disability gap. This section begins by summarizing the major findings of the study. A discussion of the study's strengths and limitations follows, and, finally, implications are discussed.

Summary of Major Findings

The black/white disability gap among older adults. This dissertation study began with investigating the difference between older black and white adults in the timing of onset of each ADL/IADL disability. The differences in survivor functions between blacks and whites were tested by both stratified log rank tests (unweighted sample) and Wald χ^2 tests based on Cox models (weighted sample). As hypothesized, survivor functions for the two groups were significantly different ($p < .001$) for all ADL/IADL indicators. Black respondents had a higher risk to become disabled than white respondents. These findings were consistent with previous studies.

This study provided more specific and complete information on the black/white disability gap by separately investigating 12 indicators of ADL/IADL disability, which was not done in the previous studies. It was found that the black/white disability gap varies greatly among ADL/IADL indicators. Among the 12 ADL/IADL indicators, the largest difference between the two groups was in difficulty in using a map ($\chi^2 = 140.04, p < .001$) followed by difficulty with managing money ($\chi^2 = 63.71, p < .001$). The smallest difference between the two groups was in difficulty with making a telephone call ($\chi^2 = 14.85, p < .001$) followed by difficulty with taking medications ($\chi^2 = 16.13, p < .001$).

Median survival ages obtained from the Kaplan-Meier estimates ranged from 85

(difficulty with using a map) to 95 (difficulty with eating) for white respondents, and from 74 (difficulty with using a map) to 93 (difficulty with eating) for black respondents. Both blacks and whites approached the median survival age earliest in difficulty with using a map, followed by mobility-related disabilities (i.e., difficulty with walking across room and with shopping for groceries) and difficulty with dressing. For all disability indicators, the median survival age of white respondents was higher than that of black respondents. The age difference between two groups ranged from 2 years (difficulty with eating and with taking medications) to 11 years (difficulty with using a map).

Changes in the black/white disability gap over time. Previous studies about changes in the black/white disability gap with advancing age produced inconsistent results. While some studies (Clark et al., 1993; Johnson, 2000) reported that the gap decreased or even reversed with over time as individuals transitioned into the oldest ages, a few other studies (Clark, 1997; Hayward et al., 2000) reported that the gap continued well into the oldest ages.

To investigate changes in the black/white disability gap over time among older adults, this dissertation study examined the survivor and the hazard functions for blacks and whites of each disability onset with age as time unit. Notable differences in survivor and hazard functions between the two groups were found across all disability indicators, as depicted in Figures 3 and 4. Importantly, this study found that the black/white disability gap depended heavily on the respondent's age. In general, the risk of becoming disabled among black respondents was higher until they entered their mid-80s. Thereafter, white respondents became more at risk to become disabled. This disability crossover phenomenon was found in the hazard functions for all disability indicators except difficulty with using a map. Because

this study utilized a nationally representative sample from 11 years of longitudinal data (RAND HRS, 1998-2008), findings of this dissertation study are more robust and generalizable than previous studies.

The disability crossover phenomenon between black and white older adults can be explained by selective mortality and differences in individual characteristics between two groups. The two explanations are not distinct because mortality is highly influenced by disease, health behaviors, and socioeconomic background. Selective mortality posits that black respondents have a shorter life expectancy than white respondents. Therefore, at the oldest ages, black survivors are physically and mentally stronger than white survivors (Ozawa & Yeo, 2008; Taylor, 2008).

As seen in Figures 5 and 6, the disability crossover phenomenon was not found for all disability indicators when disease, health behaviors, and SES were controlled for. When these factors were controlled for, survival and the hazard functions for most disability indicators became almost identical. These findings suggest that the changes in the black/white disability gap with advancing age are a reflection of differences between the black and white respondents in disease, health behaviors, and SES at certain ages.

Mediating roles of SES, diseases, and health behaviors. As hypothesized, this study found that SES was the leading contributor to the black/white disability gap among older adults for all disability indicators. This result is consistent with previous studies (August & Sorkin, 2010; Guralnik et al., 1993; Fuller-Thompson et al., 2009; Kelley-Moore & Ferraro, 2004; Kington & Smith, 1997; Ozawa & Yeo, 2008; Song et al., 2007; Mendes de Leon et al., 2005; Schoeni et al., 2005; Taylor, 2008).

On average across all 12 disability indicators, controlling for the SES factor (i.e.,

education, income, and net worth) narrowed the black/white disability gap by 67.7%. The amount of the decrease ranged from 46.0% (difficulty with eating) to 88.8% (difficulty with taking a medication). For six of the disability indicators (difficulty with walking across a room, bathing, getting in and out of bed, making a phone call, taking a medication, and shopping for groceries), the black/white disability gap became non-significant when the SES factor controlled for.

Controlling for the health behaviors factor (BMI, drinking, smoking, and vigorous activity) narrowed the gap by an average of 30.8% among all disability indicators. The greatest decrease was for mobility-related disabilities (51.4% for difficulty with walking across a room and 42.4% for difficulty with shopping for groceries), and the smallest decrease was for difficulty with using a map (12.5%).

Controlling for the disease factor (hypertension, diabetes, cancer, lung disease, heart disease, stroke, arthritis, and psychiatric or memory-related problems) narrowed the disability gap by an average of 13.2% across all 12 disability indicators, ranging from 0.1% (difficulty with using a map) to 26.1% (difficulty with walking across a room). In general, the mediating role of disease was more apparent among ADL indicators than among IADL indicators.

It is noteworthy that the amount of decrease in disability gap caused by controlling for all three factors (disease, health behaviors, and SES) was similar to that caused by controlling only the SES factor. This finding implies that these three factors are not distinct; rather, they are highly related to each other.

Although the black/white disability gap decreased substantially when controlling for all three mediating factors (SES, disease, and health behaviors), there were still significant

disability gaps for six disability indicators (difficulty with dressing, eating, toileting, using a map, managing money, and preparing hot meals). This finding suggests that there are other important mediators (e.g., built environments, prejudice and discrimination, social capital, supports from family and relatives) that contribute to the unexplained black/white disability gap among those six indicators.

Predictors of timing of disability onset. This study found a few interesting results regarding predictors of disability onset among older black and white respondents. However, it is important to note that the findings discussed here are based on a sample of non-Hispanic blacks and non-Hispanic whites; thus, these findings are not generalizable to the entire older adult population in the U.S.

First, in a bivariate relationship, living status was highly related to the timing of disability onset. The median survival ages across all disability indicators were highest for respondents living with a spouse and lowest for those living alone. These findings are consistent with previous studies reporting a higher risk of becoming disabled among older persons living alone (Lund, Nilsson, & Avlund, 2010; Nilsson, Lund, & Avlund, 2008; Waite & Hughes, 1999). However, after controlling for all covariates, this study found that there were no significant differences in any indicators in the timing of disability onset between older persons living with a spouse vs. those living alone. This implies that there are possible strong mediators affecting the relationship between living status and disability. A close investigation of a relationship between living status and disability is needed in a future study.

Second, this study found that all three factors (disease, health behaviors, and SES) significantly affected the timing of disability onset across all disability indicators. A series of likelihood tests (see Appendix E) showed that inclusion of each factor improved model fit to

a highly significant extent. These findings reconfirm the validity of the disability process model (Verbrugge & Jette, 1994), which posits that the source of disability is the interaction between functional limitation (caused by impairments and disease) and various intra- and extra-individual characteristics such as health behaviors, socioeconomic background, demographics, social supports, built environments, prejudice, and discrimination. Interestingly, this study also found that the relative importance of the three factors (disease, health behaviors, and SES) greatly differed across disability indicators. In general, the importance of the disease factor was highlighted in ADL and mobility-related indicators (difficulty with walking across a room and shopping for groceries). The health behaviors factor was more important for mobility-related indicators than other indicators. The contribution of the SES factor was more accentuated among IADL indicators than ADL indicators with a few exceptions such as difficulty with taking medications.

Third, unlike health behaviors and disease, the effect of each SES-related component varied substantially across disability indicators. For example, education was a significant predictor for most IADL disabilities. Net worth was an important determinant of the timing of onset for most of the ADL and IADL disabilities studied. However, the effect of income was present only for two disability indicators, difficulty with bathing and getting in and out of bed. Given that both income and net worth represent the financial resources of respondents, the differences between income and net worth in their effect on disability onset are noteworthy.²²

The relatively higher importance of net worth over income in disability onset among

²² To explore this issue further, each disability indicator was re-analyzed by excluding net worth to estimate the changes in significance of income. Income became significant for difficulty with walking across a room, bathing, eating, and getting in/out of bed and marginally significant for difficulty with dressing, using the phone, and managing money.

older adults can be explained in three ways. First, income pays for daily living costs (e.g., rent, food, regular bills), but net worth (e.g., wealth, assets) contributes more to provide a buffer against unexpected medical expenses. Therefore, net worth is expected to play a more important role in preventing disability caused by unexpected disease or injury. Second, income reflects a respondent's SES at a certain time (i.e., flow). However, net worth represents a respondent's SES in an accumulative way (i.e., stock). Bowen (2009) found that childhood SES significantly affected disability onset in older age. This result indicates that the development of disability is influenced not only by current SES, but also by previous SES. Therefore, net worth can be regarded as a more important component of SES than income, especially for older persons. Third, the variation in the amount of net worth among older adults is much greater than that of income.²³ Social Security has tremendously decreased poverty among the elderly²⁴ and has resulted in a substantial narrowing of income variation among that group. As an independent variable, the greater variation in net worth provides more predictive and explainable power than the smaller variation in income.

Strengths and Limitations

This study contributes to previous studies of the black/white disability gap among older adults in several ways. First, this study provides important information on the black/white disability gap according to 12 separate indicators of ADL/IADL disability. Findings from previous studies, which used aggregate measures of ADL/IADL disability, were limited and incomplete and could not provide a comprehensive examination of the racial disability gap among older adults.

²³ Based on the baseline (wave 4), this author found that the coefficient variation (s.d./mean) was 0.30 for net worth and 0.14 for income. A greater coefficient variation indicates a larger variation in a given variable.

²⁴ Van de Water and Sherman (2010) reported that the poverty rate among the elderly (65 years and older) was 9.7%. By excluding Social Security, the rate increased to 45.2%.

Unlike previous studies that relied on regional samples, cross-sectional data, or longitudinal data with a shorter time period, this study utilized a nationally representative sample with 11 years of longitudinal data. The data for this study are also more recent compared to that used in previous studies. Furthermore, the black/white disability gap was investigated using a wider age range by expanding the study sample to include older adults ages 50 and older, instead of limiting the sample to adults ages 65 and older or even 70 and older.

This study employed an advanced statistical method—survival analysis with age as time scale. Although a few previous studies (Dunlop et al., 2007; Song et al., 2007) used survival analysis to investigate the timing of disability onset among older adults, their time scales were defined by a time-in-study approach (the elapsed time from entry into the study until the event of interest occurs). Although age as time scale in a survival analysis has been recommended for studies of older adults because of a strong relationship between age itself and disability (Korn et al., 1997; Lamarca et al, 1998), this approach has not been widely applied in previous studies. By employing age as time scale, this study was able to examine two important topics at the same time: changes in the black/white disability gap by an individual's age, and factors that mediate that gap. Additionally, utilizing age as time scale allows findings to be presented in a more intuitive and efficient way.

Finally, the findings of this study were confirmed by two survival models: survey-based analysis and the LWA model. Following the guidelines of the RAND HRS, this study used the survey-based model to account for a multistage area probability sample. This study also reanalyzed the data by using the LWA model to correct a possible clustering effect (i.e., respondents residing in a same household may share similar characteristics and outcomes).

The findings from both models were very similar.

Despite these strengths, this study also has several limitations. First, it utilized eight disease variables (hypertension, diabetes, cancer, lung disease, heart disease, stroke, psychological or memory-related disease, and arthritis) to represent the disease factor. While this list of diseases is comprehensive, it is incomplete because it fails to include many other diseases that are prevalent among older adults.²⁵ For example, there are no measures of kidney disease, bone disease, asthma, eye conditions (cataract and glaucoma), skin disease, or oral disease. Moreover, the severity of each disease cannot be captured by the dichotomous measure used in this study. Differences between older black and older white adults in diseases not included in this study, as well as differences in disease severity, may affect the black/white disability gap.

Second, the data for this study were collected every two years. Therefore, the timing (i.e., age) disability onset was not precisely measured. For example, a respondent who first reported having a disability at age 65 may have started to have that disability between ages 63 and 65. Because this study specifically focused on the age of onset of a given ADL or IADL disability by utilizing age as time scale, the concern regarding the imprecise measure of age of disability onset is worth noting.

Third, this study found that three mediating factors (disease, health behaviors, and SES) explained most of the black/white disability gap among older adults. However, it also found that black respondents still had a higher risk of becoming disabled for all disability indicators even after controlling for those three factors. Although the higher hazard ratio for

²⁵ The American Society of Consultant Pharmacists identified diabetes, arthritis, kidney problems, dementia, Parkinson's disease, glaucoma, lung disease, cataracts, osteoporosis, enlarged prostate, Alzheimer's disease, macular degeneration, depression, and cardiovascular disease as the most prevalent chronic diseases among the elderly living at home (Parentgiving, 2011).

blacks of becoming disabled was not statistically meaningful for many of the disability indicators, black respondents did have a significantly higher risk to become disabled for some indicators (difficulty with dressing, eating, toileting, using a map, managing money, and preparing hot meals). These findings suggest that there are other important mediators that affect the unexplained black/white disability gap found in this study. Previous studies reported several correlates or causes of disability in old age, such as housing and neighborhood conditions (Beard et al, 2009; Clark & George, 2005; Glymour, Mujahid, Wu, White, & Tchetgen, 2010), social support (Barnes, Mendes de Leon, Wilson, Bienias, & Evans, 2004; Mendes de Leon, Glass, & Berkman, 2003; Peek et al., 2003), social networks (Jang et al., 2003), community participation (Janke et al., 2008), and self-efficacy (Mendes de Leon et al., 1996). Cultural differences between older black and white adults may also account for the unexplained black/white disability gap found in this study. Further research is warranted that includes a more comprehensive set of possible mediators in the relationship between race and the risk of disability among older adults.

Fourth, like most large-scale public data sets (e.g., SIPP, PSID),²⁶ the RAND HRS is based on self-reported responses. Therefore, the data are subject to misreporting and measurement errors. In particular, researchers in medical fields have questioned the use of the RAND HRS to investigate health disparities because of its lack of objective performance-based measures of individual functions and imprecise measures of chronic diseases (Hayward, 2002). Although the limitations of self-reported measures applied to most covariates (e.g., diseases, health behaviors, income, and net worth), it is not a critical

²⁶ Unlike most popular large scale data used for the studies on elderly, EPESE (Established Populations for Epidemiologic Studies of the Elderly) has physical function tests such as walking speed, repeating chair stands, and standing balance. However, the sample is not nationally representative. The 2006 HRS also provided standardized physical function tests such as hand grip strength, balance tests, and time work for a random subsample.

limitation to the measure of disability. In this study, disability is defined as the inability to perform specific self-care and social roles in everyday life. In other words, disability is a gap between personal capability and socio-cultural environments. Importantly, disability needs to be subjective in this definition. Therefore, it is not a major limitation of this study to examine the black/white disability gap based on ADLs and IADLs.

Fifth, there are potential biases in the results because of differential loss to follow-up (due to death or loss to contact) between black and white respondents. The characteristics of the lost-to-follow-up cases may differ between the two groups. These differences may produce attenuation in the hazard ratio estimation because the measurement error variance is heterogeneous (i.e., unobserved heterogeneity). These lost-to-follow-up cases are called random censoring in survival analysis, and the proportion ranged from 26.7% (difficulty with dressing) to 29.5% (difficulty with eating) of the total sample. Although this dissertation study conducted sensitivity analysis to estimate the influence of the random censoring on the study results,²⁷ this sensitivity analysis could not accurately account for the unobserved heterogeneity that may present in the data.

Implications

Research implications. This study found that the black/white disability gap differed by each disability indicator. In addition, the relative contribution of each disease, health behaviors, and SES factor greatly varied among the disability indicators. This finding suggests that using ADLs and IADLs as an aggregate measure to investigate the racial disability gap provides a limited understanding of the issue. Notably, difficulty with using a map produced very different outcomes compared to other disability indicators. Unlike other

²⁷ See the sample section in the Methods for detailed information on the sensitivity analysis of the random censoring.

indicators, a disability crossover was not found in difficulty with using a map (Figure 4), suggesting persistent disability inequality with advancing age. After controlling for the three mediating factors (i.e., disease, health behaviors, and SES), the black/white disability gap was still noticeably present in the model-predicted hazard curve (Figure 6) for difficulty with using a map. The median survival age for this indicator of disability was the lowest among the 12 indicators used in this study (Table 2). These noticeably different results for difficulty with using a map compared to the other disability indicators implies that the indicator using a map may measure a different construct than the other disability indicators. Wallace and colleagues (2004), using the measures for functional limitation and disability in the HRS, found that difficulty with using a map failed to be loaded in the factors that the other ADL/IADL instruments were loaded in.²⁸ ADLs and IADLs aim to measure an individual's functional ability to carry out daily tasks to live independently in a community. When we consider that among older adults, using a map is not as common or as important as the other activities that are disability indicators for independent daily living, it is questionable to use difficulty with using a map as a component of IADLs.²⁹ Therefore, it is imperative to make a close examination of the construct validity of IADL disability when studies use an aggregate measure of IADL disability that includes difficulty with using a map as a component of IADLs.

Consistent with the previous literature, this study reconfirmed SES as the leading contributor to the black/white disability gap. However, it is still unclear which component(s)

²⁸ Using the factor analysis with oblique rotation, Wallace et al. (2004) found three factors: factor 1 included most functional limitation instruments; factor 2 contained all ADL components and 2 IADL components (difficulty with shopping and preparing hot meals); and factor 3 loaded 3 IADL components (difficulty with making a phone call, taking medications, and managing money). However, difficulty with using a map did not load in any of the above three factors.

²⁹ In reviewing 9 large-scale public surveys (ACS, HRS, MCBS, MEPS, NHANES, NHIS, NLTCS, SIPP, and SOA) Waidmann and Freedman (2006) found that the HRS is the only survey that includes "difficulty with using a map" as a component of disability measure.

of SES (i.e., education, income, and/or net worth) plays a primary role in explaining the racial gap for each disability indicator. This study found by investigating influential variables to predict the timing of disability onset (Tables 6 and 7), the significance of each SES component greatly varied by disability indicator. Therefore, it is reasonable to expect that the role of each SES component in the black/white disability gap will differ for each disability indicator. Further studies are needed to examine this issue in order to provide a better understanding of the relationship between each SES component and the black/white disability gap.

To gain a better understanding of the racial disability gap, further studies are also needed to examine the risk factors of for disability onset in older adults separately for whites and blacks. This dissertation study found that the black/white disability gap was mostly caused by differences in SES, health behavior, and diseases between older black and white adults. However, this study did not focus on the important topic of the differing effect of each covariate on the risk of disability for older blacks and whites respectively. In a future study, those moderating effects need to be investigated fully by testing interaction terms between the race variable and each covariate, or by examining the risk of disability for older black and white adults separately. In addition, research that examines the factors that influence the risk of disability for older black and white adults by each age cohort would provide a more comprehensive understanding of mechanisms leading to the risk of disability onset as adults age.

It is important to note that this study examined the black/white disability gap by focusing on the risk of disability onset using a dichotomized measure of onset (i.e., onset vs. no onset). Therefore, questions about the racial gap in disability severity cannot be answered

by this study. The findings of this dissertation study provide only partial information about the black/white disability gap. Findings regarding the extent of the black/white disability gap and its causes may differ according to the researcher's focus (onset of disability or severity of disability) as well by the way disability is measured (dichotomously or continuously) (Taylor, 2008). Future studies need to examine the racial gap in disability trajectory (the severity of disability) and how it changes as age increases. In addition, investigation is needed regarding disability among older Hispanic and Asian adults in light of the rapid growth of those populations in the U.S.

Practice and policy implications. This dissertation study found that SES is the most important factor in explaining the black/white disability gap, as well as an important determinant of the timing of disability onset among older black and white adults. Health behaviors and chronic disease also contributed to the black/white disability gap by some degree, but their contributions were very small compared to the role of SES. This study also found that the influence of health behaviors and disease was very minimal to the black/white disability gap when SES was accounted for. Therefore, understanding the pathway from SES to disability is very important in order to close the black/white disability gap.

Scholars have attempted to explain the relationship between low SES and the development of disability in later life. Many scholars highlighted a strong relationship between SES and health care access and quality in the older adult population (Dunlop et al., 2007; Kingston & Smith, 1997). Low SES is related to limited access to quality health care (Fiscella, Franks, Gold, & Clancy, 2000) and lower rates of private insurance (Shi, 2001), which results in a higher risk of becoming disabled. Some scholars note that elderly with low SES have a lower rate of assistive technology use, which may be associated with higher rates

of disability (Freedman, Agree, Martin, & Cornman, 2006; Rubin & White-Means, 2001).

Other researchers argue that low SES among the elderly is related to poorer health behaviors and limited knowledge about how to and the means to adjust physical surroundings to prevent chronic conditions from becoming disabling (Jagger et al., 2007). In addition, researchers note that low SES is associated with poorer physical environment such as poor housing and neighborhood conditions and that these may increase the risk of becoming disabled in older persons (Beard et al., 2009).

Therefore, practice and policy approaches to diminish the black/white disability gap need to recognize the importance of health care equity (i.e., equal access to quality care) and the important role of non-health care factors such as health behaviors and physical environment. The disablement process model posits this—that is, that disability is influenced not only by intra-individual factors (e.g., disease) but also by extra-individual factors such as health care utilization and physical/social environment.

Health care access and care quality and their contribution to the black/white disability gap was not directly analyze in this dissertation. However, because SES is strongly correlated with health care access and quality (Becker & Newsom, 2003; Fiscella, et al., 2000; Fiscella & Williams, 2004; Kingston & Smith, 1997) the finding that SES plays a significant mediating role in the black/white disability gap has important implications related to health care access and quality of care.³⁰ The black/white disability gap could be viewed in part because of a disparity in access to health care and quality of care between these two groups.

³⁰ Health care access and quality are understood here in the context of realizing that they are influenced by numerous factors such as gender (Owens, 2008), race (Cykert et al., 2010; Smedley, Stith, & Nelson, 2003), geography (Goodridge, Lawson, Rennie, & Marciniuk, 2010), immigrant status (Marshall, Urrutia-Rojas, Mas, & Coggin, 2005), and SES. Among the numerous factors that influence health care access and quality, this study focused on SES to discuss access and quality of care.

Compared to older white adults, older black adults have substantially limited financial resources, resulting in difficulty in affording private health insurance to supplement Medicare and in accessing needed health care services. In evaluating a sample of community-dwelling adults ages 65 and older, Dunlop and colleagues (2007) found that about 27% of older white persons had private health insurance, compared to 7% of older black persons. In 2008, the proportion of Medicare beneficiaries who delayed seeking care because of cost was much higher for black respondents (12%) than white respondents (8%) (Kaiser Family Foundation, 2010). Among non-institutionalized older adults ages 65 and older, the proportion of Medicare beneficiaries who did not purchase at least one prescription drug because of cost was 6.8% for older white adults and 16.4% for older black adults (Reed, Hargraves, & Cassil, 2003). According to Escarce, Epstein, Colby, and Schwartz (1993), white elderly persons were more likely to have a broad range of specific medical procedures and diagnostic tests than black elderly persons. These statistics reveal that older black adults have greater difficulty in affording and accessing health care services.

In addition to less access to health care services, older black adults also experienced lower quality of health care services than older white adults did. According to Blendon and colleagues (2009), black persons were twice as likely to rate their community health services as fair or poor than white persons (46% vs. 23%). These racial differences in the quality of health care were assumed to be caused by the lack of private health insurance among black persons, which meant that black persons had fewer choices in health services, which can compromise the quality of health care (Becker & Newsom, 2003). However, many scholars (Kressin & Petersen, 2001; Kressin, Raymond, & Manze, 2008; Snowden, 2003; Van Ryn, 2002; Van Ryn & Fu, 2003) have also claimed that the black/white difference in the

perceived quality of health care is a reflection of black respondents experiencing bias and discrimination in their interactions with health care providers. Because of lower perceived quality among black persons, as compared to whites, they have less trust in their health care providers but greater trust in informal health information sources (Musa, Schulz, Harris, Silverman, & Thomas, 2009).

Lower SES among older black adults also contributes to less access to special equipment needed while living with chronic conditions and to compensate for environmental barriers. Compared to older white adults, older black adults have fewer financial resources and lower rates of private insurance, resulting in being unable to afford costly medical equipment (Brown & Lynch, 2005). According to a recent study by Kaye, Yeager, and Reed (2008) based on a sample from 20 California Independent Living Centers, the mean number of devices used among white persons ($n=2.3$) was close to two times greater than that among black persons ($n=1.4$). However, the difference in the number of devices between white and black persons became non-significant when SES indicators such as income and education were controlled. This result implies that their SES caused the difference between older black and white adults' access to assistive devices.

It is clear that timely delivery of quality health care lowers the risk of disability and decreases the black/white disability gap, and it is especially important for older adults because of the increased medical needs caused by aging. Although Medicare and Medicaid play a significant role in covering elderly persons' medical care, many older black adults do not receive affordable and adequate health care in a timely manner because of the lack of financial resources to cover qualified private insurance premiums and a high rate of out-of-pocket spending. To alleviate the racial gap in the accessibility and quality of health care,

policymakers need to pay more attention to the design of an efficient and affordable health care delivery system, especially for low-income older persons. It is important to recognize that strengthening the health care safety net for low-income older persons also contributes to a decrease in the black/white disability gap (Fiscella & Williams, 2004).

The findings of this dissertation study also highlight the importance of integrated care for older adults, not only to decrease the risk of becoming disabled, but also to alleviate the black/white disability gap. As Becker and Newsom (2003) claim, the health care gap between older black and white adults is a structural problem in the current health care delivery system in the U.S. This structural problem includes a fragmented delivery system,³¹ heavily institutionally based services, and a focus on medical intervention while neglecting the importance of supporting social services. This fragmented and medically focused intervention is also problematic in effectively preventing disability in old age, as well as in alleviating the racial gap in disability in old age. According to the disablement process model, disability can be prevented or alleviated by both improving a person's functional capability through medical interventions and by reducing environmental demand through social and community interventions (Verbrugge & Jette, 1994). Although disability has long been regarded as a personal matter based on the medical perspective or what is referred to as the person-centered perspective (Capitman, 2003), it is clear that medical intervention is only a part of the multifaceted approach to prevent or alleviate disability among the elderly. Rather, disability can also be prevented or alleviated through activity accommodations; modification of built, physical, and social environment; psychosocial coping; and external support by personal assistance and special equipment.

³¹ The U.S. health care system for the elderly has been criticized for fragmentation of services that result in higher costs and difficulty in access to services. For details, see the following references: Alper & Gibson (2001); Cebul, Rebitzer, Taylor, & Votruba (2008); and Leutz (1999).

A holistic view of disability requires that the medical care system and the social care system be integrated to respond to older adults with higher risks of being disabled because of their chronic conditions (Katz, 2004). As Capitman (2003) highlighted, the coordination or integration of health care with social care (i.e., community services) is a pivotal aspect of a preventive intervention strategy for disability among the elderly. Therefore, it is important that acute care, long-term care, and supportive community services be adequately coordinated and integrated to effectively prevent or alleviate disability among the elderly (Capitman, 2003; Katz, 2004; Verbrugge & Jette, 1994).

The integration of health care with social care is also important to lessen the black/white disability gap, as well as prevent disability among older adults. As this study found, the black/white disability gap was explained by various factors such as SES, health behaviors, and disease. Therefore, providing multidimensional preventive services that address the multiple and interacting risk factors related to disability would be a better approach to resolving the black/white disability gap than a strategy that focuses solely on medical care.

Since the 1990s, interest has grown in integrated care³² as a way to address the fragmentation of services to the elderly with chronic conditions (Kodner & Kyracou, 2000). For example, Stone (2000), the former Deputy Assistant Secretary for Disability, Aging, and Long Term Care in the U.S. Department of Health and Human Services, pointed out that integrated care should be one of the key directions for a successful future aging policy.

³² The term *integrated care* has different meanings depending upon the study. Some studies refer to integrated care as financial integration, particularly focusing on beneficiaries who are dually eligible for Medicare and Medicaid (Peters, 2005). Integrated care also has been considered as an integration in service delivery systems or organization models, in which the focus is on bridging the medical care system (i.e., acute care) and other service systems such as long-term care (Davis, 2001) or community services (Leutz, 1999). In this paper, integrated care refers to the service delivery system bridging the medical care system and other service systems.

Recognizing the limitations of traditional fragmented health services, Leutz (1999) first introduced a conceptual framework for integrated care organization models based on the integrated care systems in the United States and the United Kingdom. Later, Banks (2004) and Hollander and Prince (2002, 2008) updated Leutz's framework for the elderly with more details on linkages between medical care and social services.

An integrated care system requires a new program in which a multidisciplinary team handles health and social services holistically (Davis, 2001; Hollander & Prince, 2008; Leutz, 1999). Key characteristics of fully integrated care models were summarized by Kodner and Kyriacou (2000). These include having a population defined by enrollment, multidisciplinary team care, multiple funding streams, comprehensive health and social care, and micromanagement of services. Although physicians still play a central role in primary care in integrated care models (Kodner & Kyriacou, 2000), the roles of various other providers (such as physical therapists, recreation therapists, nurses, home care and personal care coordinators, program managers and staff, nutritionists, and social workers) are as important as the physician's (Cheh, 2006; Harshaw-Ellis, n.d.). In the integrated care model, for example, social workers work as case managers, helping recipients determine their social needs, arranging and coordinating adequate services, and supervising enrollment and care management (Harshaw-Ellis, n.d.). Advantages of fully integrated care services over traditional fragmented services have been viewed in various ways: eliminating duplication and fragmentation of services (Alper & Gibson, 2001; Davis, 2001; Hollander & Prince, 2008; Kodner & Kyriacou, 2000; Leutz, 1999; MacAdam, 2008); consumer-directed and consumer-oriented services, which improves communication between the consumer and

service providers (Kodner, 2001, 2003); and lower health care costs while increasing service quality and service satisfaction (Alper & Gibson, 2001; Davis, 2001; Kodner, 2001).

Several programs for the elderly in the United States are considered to be integrated care models: the Program of All-Inclusive Care for the Elderly (PACE), Social Health Maintenance Organizations (Social HMO), Minnesota Senior Health Options, Arizona Long Term Care System (ALTCS), EverCare, and Medicare+ Choice. Although these models provide both medical care and social care simultaneously through a multidisciplinary care team, the characteristics of each program vary in terms of target population, funding, types of services, and degrees of integration. For example, PACE is focused on the frail elderly ages 55 and older. Social HMO is designed for Medicare-eligible elderly ages 65 and older. ALTCS covers low-income elderly and persons with disabilities. EverCare targets permanent nursing home residents. Among integrated care programs for the elderly in the United States, PACE frequently has been cited as the most successful example of a fully integrated care model (Kodner, 2003; Kodner & Kyriacou, 2000; MacAdam, 2008). PACE also was one of the first elderly care programs listed as an evidenced-based model of care by the U.S. Department of Health and Human Services (National PACE Association, n.d.).

The effectiveness of integrated approaches for the elderly was demonstrated by various studies. For example, Beswick and colleagues (2008) conducted a meta-analysis based on 89 evaluation studies of complex intervention programs for the frail elderly around the world. They found that community-based multi-factorial programs providing medical care and various community services positively affected physical functioning among the elderly and decreased the risk of becoming disabled. Specifically focusing on PACE, participants of PACE were found to have lower hospital and nursing home admissions and

stays (Sands et al., 2006), higher utilization of support services (Chatterji, Bustein, Kidder, & White, 1998), lower mortality rates (Chatterji et al., 1998), better quality of life (Pacala, Kane, Atherly, & Smith, 2000), and higher health status and functional status (Mukamel et al., 2007).

In spite of the effectiveness of integrated care models, most older adults in the U.S. do not have an opportunity to participate in these programs because of limited program capacity. For example, the average number of participants at each PACE site is only 240 (Mukamel et al., 2007). Furthermore, minority elderly persons as compared to whites were more likely to drop out of integrated care programs because of the cost (Leutz et al., 2002; Lorig et al., 2001). According to a recent estimate by the National Registry of Evidence-Based Programs and Practices (NREPP) (2008), Medicaid-only eligible participants required about \$3,000 of additional monthly payments to participate in PACE. This is the main reason why almost all PACE participants have been dually eligible beneficiaries for Medicaid and Medicare. Thus, a wider expansion of integrated care programs in the U.S. largely depends on the government health care policy to support older adults with financial limitations. More effective and efficient financial support for low-income older adults needing integrated health care and social services will help prevent or alleviate disability, as well as decrease the racial gap in disability among older adults.

Conclusion

In the traditional medical perspective on disability, disability generally has been considered solely a health issue. This perspective views disability as a direct consequence of medical conditions such as injury or disease. Disability among the elderly is also viewed as an inevitable process as people age. Consequently, the black/white disability gap was largely

explained by biological differences between the two groups. However, the disablement process model posits that disability is not only the result of functional limitation caused by chronic conditions and impairments, but also the result of interactions between functional limitations and social, economic, psychological, and environmental factors. Specifically, the disablement process model explains that the process from chronic or acute conditions to disability is moderated by various intra- and extra-individual factors.

The findings of this dissertation study support the disablement process model. By examining 12 ADL/IADL indicators separately, this study found that the black/white disability gap was mostly explained by SES. Health behavior and disease also contributed to the gap by some degree. This study also found that the disability crossover phenomenon that occurs with increasing age was removed for most disability indicators when SES, health behaviors, and disease were controlled. These findings clearly show that the disability disparity between older black and white adults is not solely a matter of racial differences in chronic conditions but rather a product of multi-factorial risks, with SES being the most important. Given that the black/white disability gap is caused by various intra- and extra-individual factors, holistic approaches, such as integrated care programs, should be employed more widely in the U.S.

Although many previous studies examined the black/white disability gap, this study is unique in that it explored 12 ADL/IADL indicators separately using age as time scale in an 11-year longitudinal data set. This study contributes to the literature by providing a more comprehensive understanding of the black/white disability gap.

Appendix A:

Summary of Previous Studies on Disability and the Racial Disability Gap in Older Adults in the U.S.

Study	Focus	Design	Data and Sample	Analysis	Measure of disability (Dependent variable)	Major findings
Andresen & Brownson (2000)	Change in severity	Cross-sectional	Telephone interviews (18 month follow-up) using a cluster sampling technique. Women age 40 and older (N=2,922).	Logistic regression	ADLs (dichotomous)	White women were more likely to report disability than black women.
August & Sorkin (2010)	Prevalence	Cross-sectional	California Health Interview Surveys (2005, 2007). Adults age 55 and older residing in California (n=40,631).	Survey-based logistic regression	ADLs (dichotomous)	Blacks age 55 to 64 were more likely to report disability, as were blacks age 75 and older.
Clark (1996)	Risk of becoming disabled	Longitudinal	Longitudinal Study on Aging (LSA, 1984-1990). Adults age 70 and older unable to walk one-quarter mile (N=3,677).	Survival analysis	5 functional limitation indicators (dichotomous)	Walking frequency decreased the risk of becoming disabled for both black and white older adults.
Clark (1997)	Prevalence	Cross-sectional	National Long Term Care Surveys (1982, 1984, 1989). Black and white adults age 65 and older (N=34,519).	Logistic regression	ADLs (dichotomous)	The rate of disability was substantially greater in all years for blacks compared to whites.
Clark et al. (1993)	Trajectory	Longitudinal	LSA (1984-1990). Adults age 70 and older (N=5,150).	Survival analysis	ADLs, IADLs (continuous)	Racial differences in disability were age-dependent. SES did not fully account for the differences.
Dunlop et al. (2007)	Risk of becoming disabled	Longitudinal	Health and Retirement Study (HRS, 1998-2004). Non-disabled adults age 65 and older (N=8,161).	Survival analysis	ADLs (dichotomous)	The racial disability gap substantially decreased by SES.

Study	Focus	Design	Data and Sample	Analysis	Measure of disability (Dependent variable)	Major findings
Fuller-Thompson et al. (2009)	Prevalence	Cross-sectional	American Community Survey (2003). Non-Hispanic black and white adults ages 55 to 74 (N=202,956).	Logistic regression	ADLs (dichotomous)	The black/white disability gap substantially decreased by SES.
Guralnik et al. (1993)	Risk of becoming disabled	Longitudinal	Piedmont Health Survey of the Elderly (1986). Adults age 65 and older in North Carolina. (N=4,057)	Survival analysis	ADLs (dichotomous)	“An active life expectancy” (disability-free life) varied by race and education level.
Hayward et al. (2000)	Prevalence, incidence	Cross-sectional , Longitudinal	HRS (1992, 1994). Non-Hispanic black and white adults ages 51 to 61 (n=8,231).	Logistic regression	ADLs (dichotomous)	The primary origin of the black/white disability gap is SES.
Johnson (2000)	Severity	Cross-sectional	Assets and Health Dynamics of the Oldest Old (AHEAD, 1993). Black and white adults age 70 and older (n=5,895).	Huber regression	ADLs, IADLs (continuous)	There was a black/white disability crossover at age 86.
Kelly-Moore & Ferraro (2004)	Trajectory	Longitudinal	Established Populations for Epidemiologic Studies of the Elderly (EPESE, 1986-1992). Black and white adults age 65 and older residing in North Carolina (n=4,162).	Latent growth curve	ADLs (continuous)	The black/white disability gap disappeared after controlling for SES and health indicators.
Kingston & Smith (1997)	Severity	Cross-sectional	HRS (1992). Adults ages 51 to 61 (N=9,744).	Tobit regression	A sum of 17 functional activities (not specified)	SES substantially decreased or removed the black/white disability gap.

Study	Focus	Design	Data and Sample	Analysis	Measure of disability (Dependent variable)	Major findings
Liang et al. (2009)	Group-based trajectory	Longitudinal	HRS (1996-2006). Older adults (the sample age was not specified) (N=18,486).	Group-based mixture models	A sum of ADLs and IADLs (continuous)	Older black adults had significantly higher probabilities than older white adults of experiencing poor functional disability trajectories.
Mendes de Leon et al. (1996)	Severity	Cross-sectional	Project Safety (a study of community-residing elderly in New Haven, Conn.). Adults ages 72 and older who were ambulatory (N=1,103).	OLS regression	ADLs (continuous)	The black/white disability gap varied by age. Self-efficacy was marginally related to ADLs decline after controlling for SES and health.
Mendes de Leon et al. (2005)	Change in severity	Longitudinal	Chicago Health and Aging Project (1993, 1998, 2000). Non-Hispanic black and white adults age 65 and older residing in Chicago (N=6,102).	Generalized estimating equations	ADLs (continuous)	The black/white disability gap did not vary consistently by age at baseline or over time. SES substantially reduced the black/white disability gap.
Moody-Ayers et al. (2005)	Change in severity	Longitudinal	AHEAD, 1993, 1995). Adults age 70 and older (N=5,671).	Survey-based logistic regression	ADLs (continuous)	SES and self-rated health accounted for about half of the black/white disability gap.
Mutchler & Burr (1991)	Severity	Cross-sectional	Survey of Income and Program Participation (SIPP, 1984). Black and white adults age 55 and older (N=9,803).	Tobit regression	ADLs (continuous)	The black/white disability gap was diminished by controlling for SES. The impact of SES on disability was different for blacks than for whites.
Ozawa & Yeo (2008)	Prevalence	Cross-sectional	HRS (2000). Black, white, and Hispanic adults age 62 and older (N=12,643).	Logistic regression	ADLs, IADLs (dichotomous)	SES substantially narrowed the black/white disability gap.

Study	Focus	Design	Data and Sample	Analysis	Measure of disability (Dependent variable)	Major findings
Popa et al. (2007)	Trajectory	Longitudinal	AHEAD (1995-2002). Black and white adults age 70 and older (N=4,499).	Mixed model	ADLs, IADLs (continuous)	Health behaviors closed the black/white IADL gap but not the ADL gap.
Reynolds & Silverstein (2003)	Onset	Cross-sectional	AHEAD (1993, 1995, 1998). Adults age 70 and older (N=4,228).	Logistic regression	Each ADL/IADL indicator, ADLs, IADLs (dichotomous)	Each ADL/IADL indicator was predicted by variety of different factors.
Schoeni et al. (2005)	Change in prevalence	Cross-sectional	National Health Interview Surveys (1982-2002). Adults age 70 and older (N=172,227).	Logistic regression	ADLs, ADLs/IADLs (dichotomous)	The racial disability gap had persisted over the 20-year study period.
Song et al. (2007)	Risk of becoming disabled	Longitudinal	HRS (1998-2004). Non-disabled adults with arthritis age 51 and older (N=7,257).	Survey-based survival analysis	ADLs (dichotomous)	SES and type of health insurance were substantial mediators of racial disability gap.
Taylor (2008)	Onset, trajectory	Longitudinal	Established Populations for Epidemiologic Studies of the Elderly (EPESE, 1986, 1989, 1992, 1996). Adults age 65 and older residing in North Carolina (N=3,955).	Latent growth curve, survival analysis	A sum of ADLs/IADLs (continuous), any ADL/IADL (dichotomous)	The diverging trajectories of black and white disability were fueled solely by differences in onset.
Zsembik et al. (2000)	Severity	Cross-sectional	AHEAD (1993). Adults age 70 and older (N=7,063).	OLS regression	ADLs, IADLs (continuous)	Racial differences in ADLs and IADLs evolve at various stages in the disablement process.

Note: ADLs = Activities of Daily Living; IADLs = Instrumental Activities of Daily Living.

Appendix B:

Sensitivity Analysis Testing Informative Censoring: Treating Random-Censored Cases as a Disability

Indicators	Unadj.	Model 1	Model 2	Model 3	Model 4	Model 5
<i>Walking across a room</i>						
H.R	1.230***	1.238***	1.181***	1.123**	1.004	1.010
% change	---	---	-23.95%	-48.32%	-98.32%	-95.80%
<i>Dressing</i>						
H.R	1.267***	1.280***	1.233***	1.182***	1.056	1.065
% change	---	---	-16.79%	-35.00%	-79.82%	-76.79%
<i>Bathing</i>						
H.R	1.249***	1.257***	1.205**	1.161**	1.054	1.035
% change	---	---	-20.23%	-37.35%	-78.99%	-86.38%
<i>Eating</i>						
H.R	1.167**	1.177**	1.143**	1.105*	1.080	1.074
% change	---	---	-19.21%	-40.68%	-54.80%	-58.19%
<i>Getting in/out bed</i>						
H.R	1.239***	1.249***	1.202**	1.157*	1.032	1.053
% change	---	---	-18.88%	-36.95%	-87.15%	-78.72%
<i>Toileting</i>						
H.R	1.237***	1.241***	1.198***	1.153**	1.063	1.084
% change	---	---	-17.84%	-36.52%	-73.86%	-65.15%
<i>Using a map</i>						
H.R	1.364***	1.357***	1.334***	1.280***	1.157*	1.179*
% change	---	---	-6.44%	-21.57%	-56.02%	-49.86%
<i>Making a phone call</i>						
H.R	1.170**	1.184**	1.157**	1.112*	1.004	1.015
% change	---	---	-14.67%	-39.13%	-97.83%	-91.85%
<i>Managing money</i>						
H.R	1.276***	1.286***	1.253***	1.198***	1.083	1.097
% change	---	---	-11.54%	-30.77%	-70.98%	-66.08%
<i>Taking a medication</i>						
H.R	1.130*	1.139*	1.103	1.063	1.002	1.008
% change	---	---	-25.90%	-54.68%	-98.56%	-94.25%
<i>Shopping for groceries</i>						
H.R	1.267***	1.273***	1.226***	1.161**	1.026	1.034
% change	---	---	-17.22%	-41.03%	-90.48%	-87.55%
<i>Preparing hot meals</i>						
H.R	1.225***	1.235***	1.196**	1.151**	1.082	1.080
% change	---	---	-16.60%	-35.75%	-65.11%	-65.96%

* $p < .05$; ** $p < .01$; *** $p < .001$

Note: H.R. represents for the hazard ratio for blacks estimated by survey-based Cox regressions.

Appendix C:

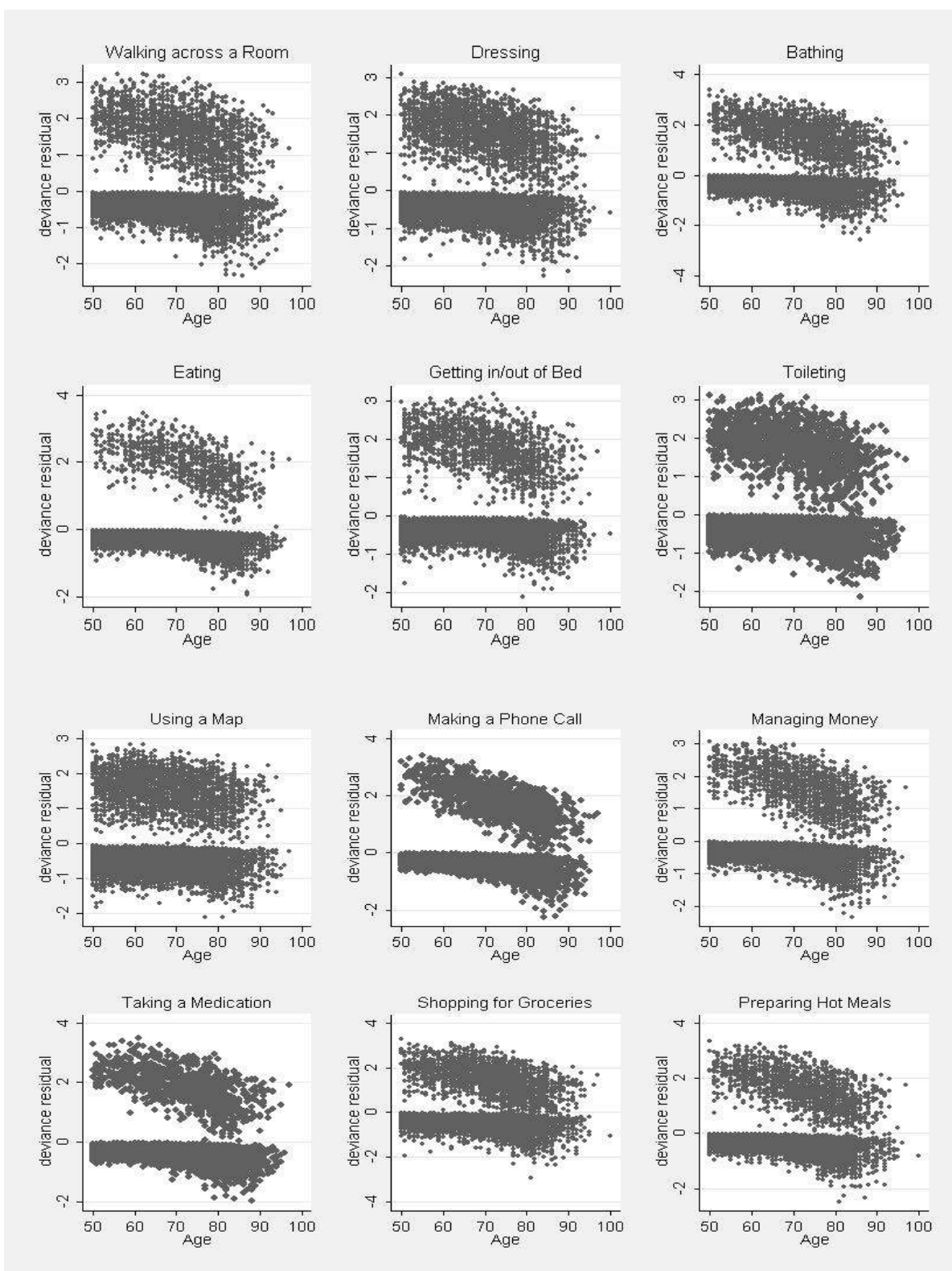
Model Diagnostics Tests

Multicollinearity. A test for multicollinearity was conducted with all covariates in this study through examining the variance inflation factor (VIF). VIF is a measure of how much the variance of an estimated regression coefficient increases if the explanatory variables are correlated. The higher the value of VIF, the greater the degree of collinearity. A VIF greater than 4 (Garson, 2010) or 10 (Kutner, Nachtsheim, & Neter, 2004) suggests multicollinearity problems and results in a poor estimation. VIF was tested by ordinary least squares (OLS) regression using the *vif* procedure in Stata. Testing multicollinearity by OLS is acceptable because the concern of multicollinearity is about the relationship among the independent variables, and the functional form of the model for the dependent variable is irrelevant to the multicollinearity estimation (Menard, 2002).

Across 12 OLS regression models for each outcome, VIF values ranged from a low of 1.03 (cancer, stroke in most disability outcomes) to a high of 2.32 (the top quintile of net worth in the outcome difficulty with shopping for groceries). Average VIF values ranged from 1.36 to 1.38. Therefore, no covariates of this study present multicollinearity problems.

Deviance residuals. Deviance residuals are useful to examine model accuracy and to identify outliers. A deviance residual is a normalized transform of the Martingale residual which estimates the difference over time between the observed number of events and the expected number of events. Observations with large deviance residuals are poorly predicted by the model, and extreme deviance residuals may indicate outliers. Deviance residuals that exceed 3 require a close examination (Allison, 1997). After running Cox regressions with all the covariates in this study (see Figure C-1), deviance residuals were plotted using

Figure C-1. Deviance Residuals by Age for ADL and IADL Indicators



Note: To calculate age, add 50 to the value on the X axis. For example, 0 indicates age 50; 10 indicates age 60, etc.

predict dev, *deviance* command following the *mgale(mg)* options of the *stcox* procedure in Stata. The plot showed a disjunction between the two groups of observations. The cluster in the lower portion of the graph represented all the censored observations, while the points in the upper portion of the graph were the uncensored observations.

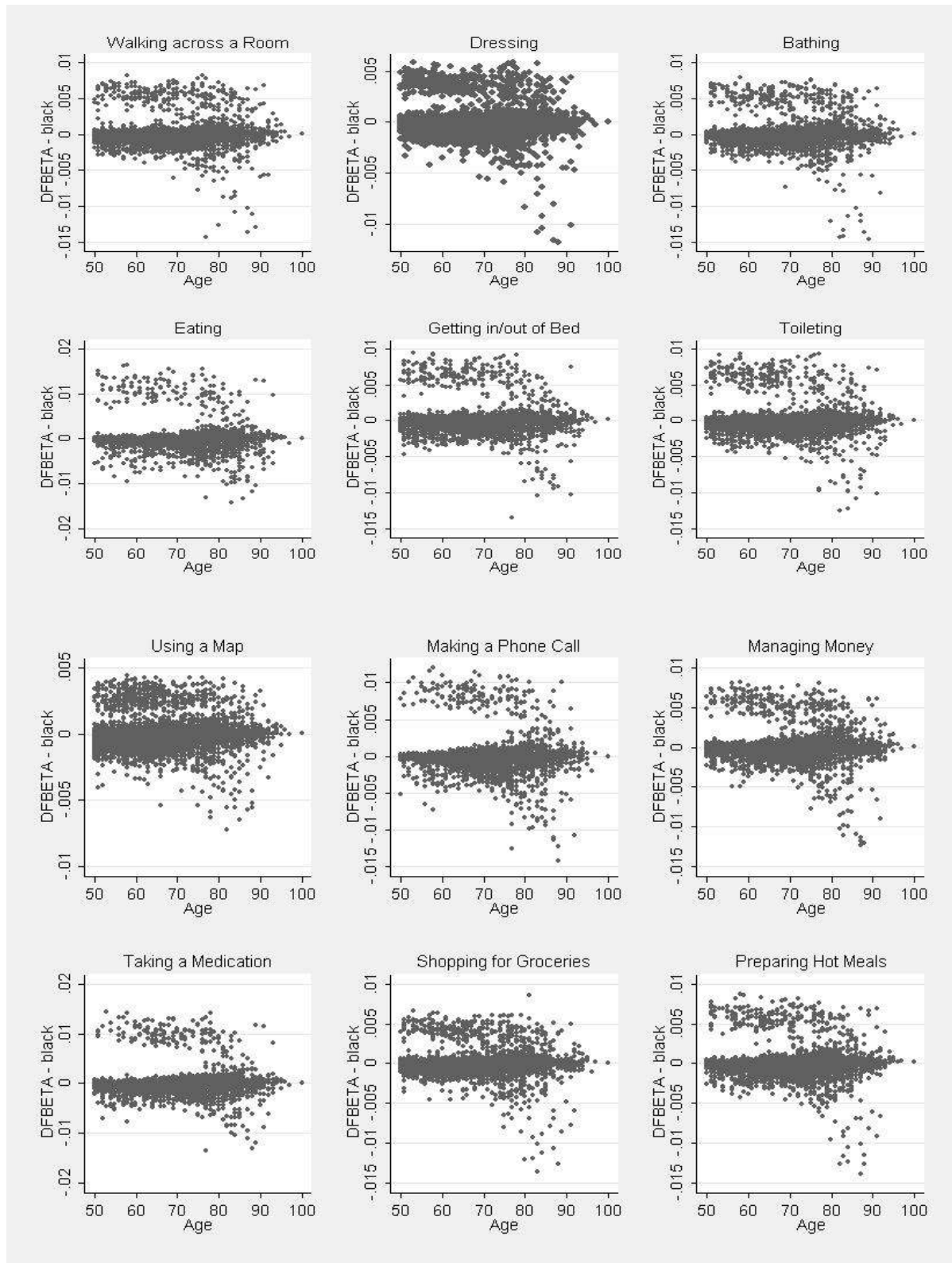
Deviance residual plots showed no extreme cases in any disability models. However, a few cases have deviance residuals greater than 3. To evaluate the influence of the cases, DFBETA tests were performed and are presented in the following section.

Influencing outliers. Based on the full model, which included all covariates, DFBETA plots were generated for the race variable by considering the research subject (the disability gap between black and white older persons). DFBETA assesses the influence of each individual observation on the change of the black population estimates due to deletion of each case. A DFBETA value in excess of 2/the square root of number of cases is recommended for further investigation (Chen, Ender, Mitchell, & Wells, 2003). In this study, the value is $0.17 = 2/\sqrt{13,429}$.

DFBETA graphs were plotted using the *predict dfbeta* procedure in Stata. As seen in the graphs in Figure C-2, the plots had several cases apart from the rest of the observations. However, their influences were likely to be minimal to change the estimates of the black population, in which a DFBETA value ranged from -.015 to .017 of all disability indicators. Therefore, they were retained in the sample.

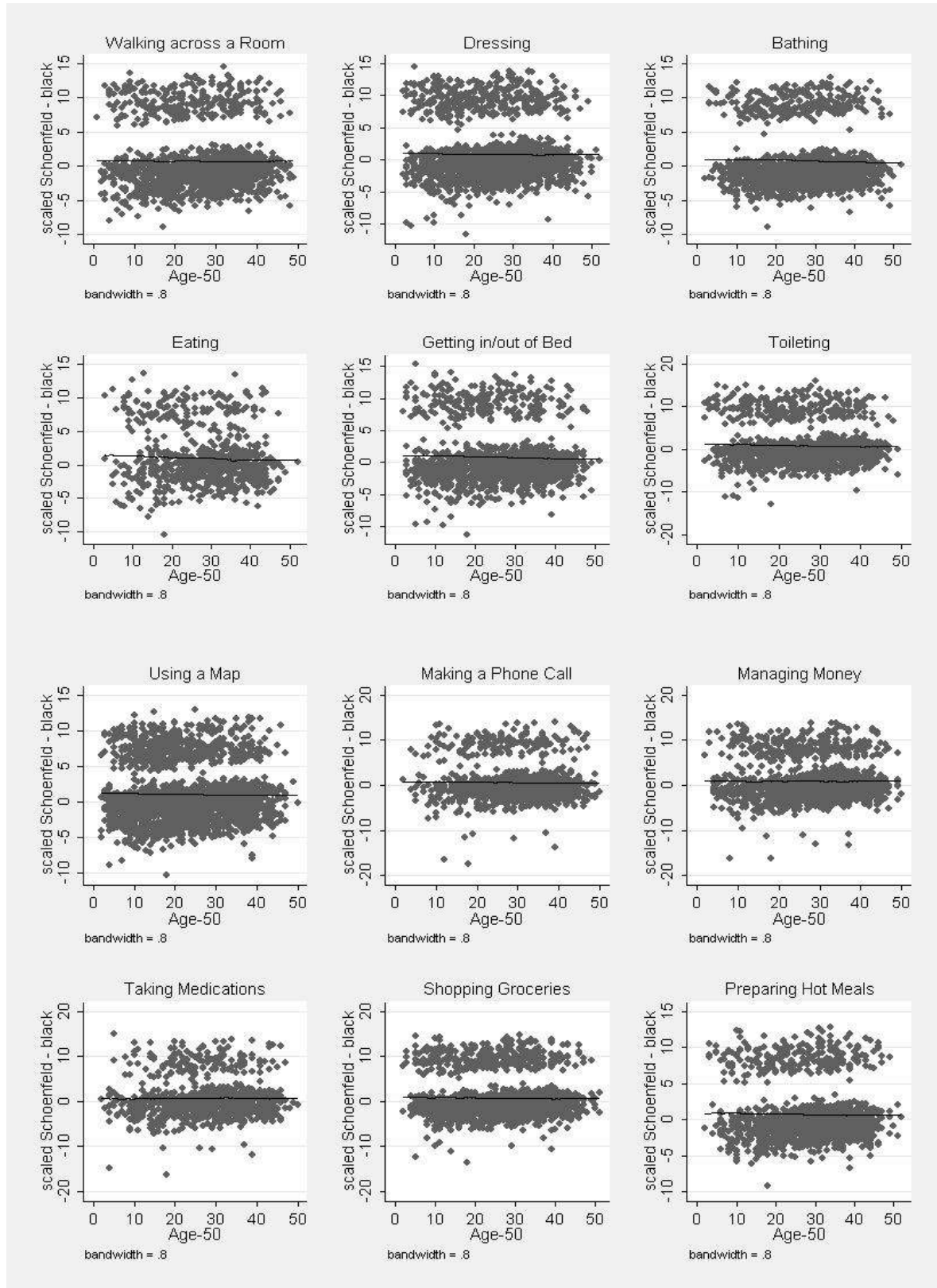
Schoenfeld residual tests. Cox regression has a proportionality assumption that the hazard functions of different individuals are proportional and independent of time. For example, the survivor functions of black and white respondents should not cross each other. The violation of the proportionality assumptions indicates the effect of a covariate on the

Figure C-2. DFBETA Influential Cases by Age for ADL and IADL Indicators



Note: To calculate age, add 50 to the value on the X axis. For example, 0 indicates age 50; 10 indicates age 60, etc.

Figure C-3. Schoenfeld Graphs for Black Respondents



Note: To calculate age, add 50 to the value on the X axis. For example, 0 indicates age 50; 10 indicates age 60, etc.

hazard ratio will vary with time. In this study, the proportionality assumption required attention, particularly for the race variable, considering that most other covariates were time-varying covariates.

Based on the full model, a proportionality assumption of black respondents was tested by the Schoenfeld residual using the *schoenfeld*, *scaledsch* and *stphtest* commands in Stata. A non-zero slope in a generalized linear regression of the scaled Schoenfeld residuals on functions of time is an indication of a violation of the proportional hazard assumption. As seen in the graphs in Figure C-3, the line of the average Schoenfeld residuals of black older persons stayed fairly straight throughout the study period for all disability indicators, implying independence between the race variable and time.

Appendix D:

Changes in Hazard Ratios for Blacks of Disability Indicators: The LWA models

Disability indicators		Unadjusted	Model 1	Model 2	Model 3	Model 4	Model 5
<i>Walking across a room</i>							
	H.R	1.595***	1.578***	1.427***	1.281**	1.102	1.053
	S.E	0.122	0.121	0.113	0.100	0.093	0.090
<i>Dressing</i>							
	H.R	1.618***	1.631***	1.532***	1.425***	1.242**	1.228**
	S.E	0.109	0.111	0.107	0.099	0.093	0.093
<i>Bathing</i>							
	H.R	1.710***	1.700***	1.564***	1.436***	1.196*	1.172
	S.E	0.130	0.130	0.126	0.111	0.099	0.100
<i>Eating</i>							
	H.R	1.850***	1.843***	1.784***	1.661***	1.455**	1.496***
	S.E	0.199	0.200	0.199	0.185	0.166	0.179
<i>Getting in out bed</i>							
	H.R	1.660***	1.651***	1.531***	1.435***	1.183	1.170
	S.E	0.141	0.141	0.135	0.126	0.111	0.111
<i>Toileting</i>							
	H.R	1.700***	1.678***	1.562***	1.438***	1.323**	1.286**
	S.E	0.144	0.143***	0.138	0.125	0.124	0.123
<i>Using a map</i>							
	H.R	1.881***	1.842***	1.841***	1.737***	1.418***	1.497***
	S.E	0.107	0.106	0.107	0.102	0.090	0.096
<i>Making a phone call</i>							
	H.R	1.559***	1.573***	1.567***	1.451***	1.125	1.167
	S.E	0.151	0.153	0.155	0.142	0.117	0.123
<i>Managing money</i>							
	H.R	1.880***	1.876***	1.824***	1.695***	1.258**	1.279**
	S.E	0.142	0.142	0.143	0.132	0.106	0.111
<i>Taking a medication</i>							
	H.R	1.430***	1.420***	1.341**	1.281*	1.047	1.054
	S.E	0.139	0.138	0.136	0.126	0.110	0.115
<i>Shopping for groceries</i>							
	H.R	1.643***	1.630***	1.521***	1.363***	1.143	1.129
	S.E	0.114	0.114	0.109	0.098	0.087	0.089
<i>Preparing hot meals</i>							
	H.R	1.679***	1.663***	1.584***	1.479***	1.256**	1.269**
	S.E	0.135	0.135	0.131	0.121	0.108	0.111

* $p < .05$; ** $p < .01$; *** $p < .001$.

Note: Findings are based on a weighted sample adjusted for clustering by households.

Appendix E:

LR Tests from Model 1 to Each Subsequent Model

Disability indicators	Model 1	Model2	Model 3	Model 4	Model 5
<i>ADLs</i>					
Walking across a room	---	415.42***	356.30***	153.12***	691.17***
Dressing	---	398.40***	269.42***	106.94***	595.96***
Bathing	---	337.28***	270.62***	163.22***	565.79***
Eating	---	106.09***	92.90***	51.33***	199.33***
Getting in out of bed	---	271.80***	159.93***	107.05***	404.91***
Toileting	---	250.74***	169.65***	61.16***	375.62***
<i>IADLs</i>					
Using a map	---	141.01***	115.62***	292.67***	450.14***
Making a phone call	---	98.08***	104.82***	119.18***	245.05***
Managing money	---	181.17***	141.47***	180.12***	391.21***
Taking medications	---	118.80***	132.89***	73.39***	260.15***
Shopping for groceries	---	455.68***	374.25***	204.62***	770.73***
Preparing hot meals	---	215.71***	173.15***	121.45***	383.43***

* $p < .05$; ** $p < .01$; *** $p < .001$.

Note: Numbers in the cells represent LR χ^2 . Tests are based on an unweighted sample. Model 1 includes demographics (gender, entering cohort, living status). Model 2 includes demographics and disease. Model 3 includes demographics and health behaviors. Model 4 includes demographics and SES. Model 5 includes demographics, disease, health behaviors, and SES.

REFERENCES

- Abberley, P. (1987). The concept of oppression and the development of a social theory of disability. *Disability, Handicap and Society*, 2(1), 5-19.
doi:10.1080/02674648766780021
- Alexopoulos, G. S., Vrontou, C., Kakuma, T., Meyers, B. S., Young, R. C., Klausner, E., et al. (1996). Disability in geriatric depression. *American Journal of Psychiatry*, 153(7), 877-885. Retrieved from <http://ajp.psychiatryonline.org/index.dtl>
- Allison, P. D. (1995). *Survival analysis using the SAS system: A practical guide*. Cary, NC: SAS Institute Inc.
- Alper, J., & Gibson, R. (2001). Integrating acute and long-term care for the elderly. In S. L. Isaacs & J. R. Knickman (Eds.), *To improve health and health care 2001*(pp.101-118). Princeton, NJ: Jossey-Bass.
- Andresen, E. M., & Brownson, R. C. (2000). Disability and health status: Ethnic differences among women in the United States. *Journal of Epidemiology & Community Health*, 54, 200-206. doi:10.1136/jech.54.3.200
- Arno, P. S. (2006). *Prevalence, hours and economic value of family caregiving*. Kensington, MD: National Family Caregivers Association.
- Ashauer, D. L. (2010). *What is normal aging? Home and family: Elder care*. Retrieved from <http://ezinearticles.com/?What-is-Normal-Aging?&id=2434570>
- August, K. J., & Sorkin, D. H. (2010). Racial and ethnic disparities in indicators of physical health status: Do they still exist throughout late life? *Journal of the American Geriatrics Society*, 58, 2009-2015. doi: 10.1111/j.1532-5415.2010.03033.x
- Avlund, K., Lund, R., Holstein, B. E., & Due, P. (2004). Social relations as determinant of onset of disability in aging. *Archives of Gerontology and Geriatrics*, 38(1), 85-99. doi:10.1016/j.archger.2003.08.003
- Baker, D. J., Eriksson, J. G., Forsen, T., & Osmond, C. (2002). Fetal origins of adult disease: Strength of effects and biological basis. *International Journal of Epidemiology*, 31(6), 1235-1239. doi: 10.1093/ije/31.6.1235
- Banks, P. (2004). *Policy framework for integrated care for older people*. Retrieved from http://www.kingsfund.org.uk/publications/kings_fund_publications/policy_frameworkor k.html.
- Barnes, L. L., Mendes de Leon, C. F., Wilson, R. S., Bienias, J. L., & Evans, D. A. (2004). Social resources and cognitive decline in a population of older African Americans

- and whites. *Neurology*, 63(12), 2322-2326.
doi:10.1212/01.WNL.0000147473.04043.B
- Barnes, C., & Mercer, G. (2010). Competing models and approaches. In *Exploring disability (2nd edition)* (pp. 14-42). Cambridge, UK: Polity.
- Barnes, C., Mercer, G., & Shakespeare, T. (1999). *Exploring disability: A sociological introduction*. Cambridge, UK: Polity.
- Barnes, C., Mercer, G., & Shakespeare, T. (2010). The social model of disability (3rd edition). In A. Giddens & P. W. Sutton. (Eds.), *Sociology: Introductory readings (3rd edition)* (pp. 161-167). Cambridge, UK: Polity.
- Beach, S. R., Schulz, R. S., Williamson, G. M., Miller, L. S., Weiner, M., & Lance, C. E. (2005). Risk factors for potentially harmful informal caregiver behavior. *Journal of the American Geriatrics Society*, 53(2), 255-261. doi: 10.1111/j.1532-5415.2005.53111.x
- Beard, J. R., Blaney, S., Cerda, M., Frye, V., Lovasi, G. S., Ompad, D., et al. (2009). Neighborhood characteristics and disability in older adults. *Journal of Gerontology Series B: Psychological Sciences and Social Sciences*, 64(2), 252-257.
doi: 10.1093/geronb/gbn018
- Becker, G., & Newsom, E. (2003). Socioeconomic status and dissatisfaction with health care among chronically ill African Americans. *American Journal of Public Health*, 93(5). 742-748. doi:10.2105/AJPH.93.5.742
- Begum, N. (1992). Disabled women and the feminist agenda. *Feminist Review*, 40(Spring), 70-84. doi:10.2307/1395278
- Bernell, S. L. (2003). Theoretical and applied issues in defining disability in labor market research. *Journal of Disability Policy Studies*, 14(1), 36-45.
doi:10.1177/10442073030140010501
- Beswick, A. D., Rees, K., Dieppe, P., Ayis, S., Gooberman-Hill, R., Horwood, J., et al. (2008). Complex interventions to improve physical function and maintain independent living in elderly people: a systematic review and meta-analysis. *Lancet*, 371(9614), 725-735. doi:10.1016/S0140-6736(08)60342-6
- Bhattacharya, J., Cutler, D. M., Goldman, D. P., Hurd, M. D., Joyce, G. F., Lakdawalla, D. N., et al. (2004). Disability forecasts and future Medicare costs. *Frontiers Health Policy Research*, 7, 75-94. Retrieved from
<http://mitpress.mit.edu/catalog/item/default.asp?tttype=2&tid=9593>
- Blendon, R. J., Scheck, A. C., Donelan, K., Hill, C. A., Smith, M., Beatrice, D. et al. (1995). How White and African Americans view their health and social problems: Different

- experiences, different expectations, *JAMA*, 273, 341-346.
doi:10.1001/jama.1995.03520280089048
- Bolen, J. C., Rhodes, L., Powell-Griner, E. E., Bland, S. D., & Holtzman, D. (2000). State-specific prevalence of selected health behaviors, by race and ethnicity behavioral risk factor surveillance system, 1997. *Morbidity and Mortality Weekly Report*, 49(ss02), 1-60. Retrieved from <http://www.cdc.gov/mmwr/>
- Bowen, M. E. (2009). Childhood socioeconomic status and racial differences in disability: Evidence from the Health and Retirement Study (1998-2006). *Social Science & Medicine*, 69, 433-441. doi:10.1016/j.socscimed.2009.06.006
- Braithwaite, V. (2000). Contextual or general stress outcomes: Making choices through caregiving appraisals. *The Gerontologist*, 40(6), 706-717.
doi:10.1093/geront/40.6.706
- Brown, J. S., & Lynch, S. M. (2005). *How does use of special equipment affect the Black-White gap in ALE?* Retrieved from
<http://paa2005.princeton.edu/download.aspx?submissionId=51191>
- Bruce, M. L., & Hoff, R. A. (1994). Social and physical health risk factors for first-onset major depressive disorder in a community sample. *Social Psychiatry & Psychiatric Epidemiology*, 29(4), 165-171. Retrieved from
<http://www.springer.com/medicine/psychiatry/journal/127>
- Bruce, M. L., McAvay, G. J., Raue, P. J., Brown, E. L., Meyers, B. S., Keohane, D. J., et al. (2002). Major depression in elderly home health care patients. *American Journal of Psychiatry*, 159(8), 1367-1374. doi:10.1176/appi.ajp.159.8.1367
- Bruce, M. L., Seeman, T. E., Merrill, S. S., & Blazer, D. G. (1994). The impact of depressive symptomatology on physical disability: MacArthur studies of successful aging. *American Journal of Public Health*, 84(11), 1796-1799.
doi:10.2105/AJPH.84.11.1796
- Capitman, J. (2003). Effective coordination of medical and supportive services. *Journal of Aging and Health*, 15(1), 124-164. doi: 10.1177/0898264302239020
- Caregiver (2010). Program eligibility criteria: Age and functional status. Retrieved from
<http://www.caregiver.org/caregiver/jsp/content/pdfs/Table%202%2010.11.04.pdf>
- Cebul, R. D., Rebitzer, J. B., Taylor, L. J., & Votruba, M. E. (2008). Organizational fragmentation and care quality in the U.S. healthcare system. *Journal of Economic Perspectives*, 22(4), 93-113. doi:10.1257/jep.22.4.93

- Cerhan, J. R., & Wallace, R. B. (1993). Predictors of decline in social relationships in the rural elderly. *American Journal of Epidemiology*, 137(8), 870-880. Retrieved from <http://aje.oxfordjournals.org/>
- Chatterji, P., Bustein, N. R., Kidder, D., & White, A. (1998). *Evaluation of the Program of All-Inclusive Care for the Elderly (PACE) demonstration: The impact of PACE on participant outcomes. Final report to the health care financing administration*. Cambridge, MA: Abt Associate, Inc.
- Cheh, V. (2006). *How integrated care programs use community-based, primary care physicians*. Retrieved from <https://www.cms.gov/reports/downloads/cheh.pdf>
- Chen, X., Ender, P., Mitchell, M., & Wells, C. (2003). *Regression with Stata*. Retrieved from <http://www.ats.ucla.edu/stat/stata/webbooks/reg/default.htm>
- Chernew, M. E., Goldman, D., Pan, F., & Shang, B. (2005). Disability and health care expenditures among Medicare beneficiaries. *Health Affairs*, w5, R42-R52. Retrieved from <http://content.healthaffairs.org/cgi/reprint/hlthaff.w5.r42v1.pdf>. doi: 10.1377/hlthaff.w5.r4
- Christakis, N., & Allison, P. (2006). Spouse's hospitalization increases partner's risk of death. *New England Journal of Medicine*, 54, 719-730. Retrieved from <http://www.nejm.org/>
- Clark, D. (1996). The effect of walking on lower body disability among older Blacks and Whites. *American Journal of Public Health*, 86(1), 57-61. doi:10.2105/AJPH.86.1.57
- Clark, D. (1997). U.S. trends in disability and institutionalization among older blacks and whites. *American Journal of Public Health*. 87(3), 438-440. doi:10.2105/AJPH.87.3.438
- Clark, D., & Maddox, G. L. (1992). Racial and social correlates of age-related changes in functioning. *Journal of Gerontology Series B: Psychological Sciences and Social Sciences*, 47(5), S222-S232. doi:10.1093/geronj/47.5.S222
- Clark, D., Maddox, G. L., & Steinhauser, K. (1993). Race, aging, and functional health. *Journal of Aging and Health*, 5(4), 536-553. doi:10.1177/089826439300500407
- Clarke, P., & George, L. K. (2005). The role of the built environment in the disablement process. *American Journal of Public Health*, 95(11), 1933-1939. doi:10.2105/AJPH.2004.054494
- Cole, M. G., & Dendukuri, N. (2003). Risk factors for depression among elderly community subjects: A systematic review and meta-analysis. *American Journal of Psychiatry*, 160(6), 1147-1156. doi:10.1176/appi.ajp.160.6.1147

- Comfort, A. (1964). *Ageing: The biology of senescence*. London, UK: Routledge & Kegan Paul.
- Congressional Budget Office. (1999). *Projections for expenditures for long-term care services for the elderly*. Retrieved from <http://www.cbo.gov/ftpdocs/11xx/doc1123/lcare.pdf>.
- Costa-Font, J. (2008). Housing assets and the socio-economic determinants of health and disability in old age. *Health & Place*, 14(3), 478-491. Retrieved from http://www.elsevier.com/wps/find/journaldescription.cws_home/30519/description#description
- Cykert, S., Dilworth-Anderson, P., Monroe, M. H., Walker, P., McGuire, F. R., Corbie-Smith, G., ... Bunton, A. J. (2010). Factors associated with decisions to undergo surgery among patients with newly diagnosed early-stage lung cancer. *The Journal of the American Medical Association*, 303(23), 2368-2376. doi:10.1001/jama.2010.793
- Davis, S. L. (2001). *Managed care and long-term care: Issues and models*. Oxford, OH: Scripps Gerontology Center.
- Dejong, G. (1979). Independent living: From social movement to analytic paradigm. *Archives of Physical Medicine and Rehabilitation*, 60, 435-446. Retrieved from <http://www.archives-pmr.org/>
- Dejong, G., & O'Day, B. (1998). *Notice of proposed long-range plan for fiscal years 1999-2004*. Washington DC: National Institute on Disability and Rehabilitation Research.
- Depoy, E. (2002). Will the real definition of disability please stand up. *SCI Psychosocial Process*, 15(1), 50-54. Retrieved from <http://psychologists-social-workers.ascipro.org/sci-psychosocial-process.html>
- Doshi, J. A., Cen, L., & Polsky, D. (2008). Depression and retirement in late middle-aged U.S. workers. *Health Services Research*, 43(2), 693-713. doi:10.1111/j.1475-6773.2007.00782.x
- Dowd, J. J., & Bengtson, V. L. (1978). Aging in minority populations: An examination of the double jeopardy hypothesis. *Journal of Gerontology*, 33(3), 427-436. doi:10.1093/geronj/33.3.427
- Dunlop, D. D., Song, J., Manheim, L. M., Daviglus, M. L., & Chang, R. W. (2007). Racial/ethnic differences in the development of disability among older adults. *American Journal of Public Health*, 97(12), 2209-2215. doi:10.2105/AJPH.2006.106047
- Elder, G. H. (1999). *The life course and aging*. Retrieved from <http://www.unc.edu/~elder/pdf/asa-99talk.pdf>

- Escarce, J., Epstein, K., Colby, D. C., Schwartz, J. S. (1993). Racial differences in the elderly's use of medical procedures and diagnostic tests. *American Journal of Public Health*, 83(7), 948-954. doi:10.2105/AJPH.83.7.948
- Ettner, S. L. (1996). The opportunity costs of elder care. *The Journal of Human Resources*, 31(1): 189-201. doi:10.2307/146047
- Family Caregiver Alliance. (2006). *Selected caregiver statistics*. San Francisco, CA: Family Caregiver Alliance.
- Feinglass, J., Lin, S., Thompson, J., Sudano, J., Dunlop, D., Song, J., & Baker, D. W. (2007). Baseline health, socioeconomic status, and 10-year mortality among older middle-aged Americans: findings from the Health and Retirement Study, 1992- 2002. *Journal of Gerontology Series B: Psychological Sciences and Social Sciences*, 62(4), S209-217. Retrieved from <http://psychogerontology.oxfordjournals.org/>
- Ferraro, K. F., & Farmer, M. M. (1996). Double jeopardy to health hypothesis for African Americans: Analysis and critique. *Journal of Health and Social Behavior*, 37, 27-43. doi:10.2307/2137229
- Ferraro, K. F. & Kelley-Moore, J. A. (2003). Cumulative disadvantage and health: Long term consequences of obesity. *American Sociological Review*, 68(5), 707-729. doi:10.2307/1519759
- Fiscella, K. & Williams, D. R. (2004). Health disparities based on socioeconomic inequities: implications for urban health care. *Academic Medicine*, 79(12), 1139-1147. doi:10.1097/00001888-200412000-00004
- Freedman, V. A. (2006). Late-life disability trends: an overview of current evidence. In M. Field, A. Jette & L. Martin (Eds.), *Workshop on disability in America: A new look* (pp. 101-112). Washington, D.C.: National Academic Press.
- Freedman, V. A., Agree, E. M., Martin, L. G., & Cornman, J. C. (2006). Trends in the use of assistive technology and personal care for late-life disability, 1992-2001. *The Gerontologist*, 46(1), 124-127. Retrieved from <http://gerontologist.oxfordjournals.org/>
- Freedman, V. A., Martin, L. G., & Schoeni, R. F. (2004). Disability in America. *Population Bulletin*, 59(3), 3-32. Retrieved from <http://www.prb.org/Publications/PopulationBulletins.aspx>
- Fuller-Thomson, E., Naru-Jeter, A., Minkler, A. M., & Guralnik, J. M. (2009). Black-white disparities in disability among older Americans. *Journal of Aging and Health*, 21(5). 677-698. doi: 10.1177/0898264309338296

- Garson, D. (2010). *Multiple Regression, from Statnotes: Topics in Multivariate Analysis*. Retrieved from <http://faculty.chass.ncsu.edu/garson/pa765/statnote.htm>
- Gibson, R. C. (1991). Age-by-race differences in the health and functioning of elderly persons. *Journal of Aging and Health*, 3, 335-351. doi: 10.1177/089826439100300302
- Gilson, S. F., & Depoy, E. (2002). Theoretical approaches to disability content in social work education. *Journal of Social Work Education*, 38(1), 153-165. Retrieved from <http://www.cswe.org/Publications/JSWE.aspx>
- Glymour, M. M., Mujahid, M., Wu, Q., White, K., & Tchetgen, E. J. (2010). Neighborhood disadvantage and self-assessed health, disability, and depressive symptoms: Longitudinal results from the Health and Retirement Study. *Annals of Epidemiology*, 20(11), 856-861. doi: 10.1016/j.annepidem.2010.08.003
- Goodridge, D.M., Lawson, J., Rennie, D., & Marciniuk, D. D. (2010). Rural/Urban differences in health care utilization and place of death for persons with respiratory illness in the last year of life. *Rural Remote Health*, 10(2), 1349-1363. Retrieved from http://www.rrh.org.au/publishedarticles/article_print_1349.pdf
- Guo, S. (2010). *Survival analysis*, New York, NY: Oxford University Press, Inc.
- Guralnik, J. M., Land, K. C., Blazer, D., Fillenbaum, G. G., & Branch, L. G. (1993). Educational status and active life expectancy among older Blacks and Whites. *New England Journal of Medicine*, 329(2), 110-116. doi:10.1056/NEJM199307083290208
- Guralnik, J.M., Fried, L. P., & Salive, M. E. (1996). Disability as a public health outcome in the aging population. *Annual Review of Public Health*, 17, 25-46. doi:10.1146/annurev.publhealth.17.1.25
- Hahn, H. (1993). The political implications of disability definitions and data. *Journal of Disability Policy Studies*, 4(2), 41-51. doi: 10.1177/104420739300400203
- Hahn, H. (1994). The minority group model of disability: Implications for medical sociology. In R. Weitz & R. R. Kronenfeld (Eds.), *Research in the sociology of health Care* (pp. 3-24). Greenwich, CT: JAI Press.
- Halfon, N., & Hochstein, M. (2002). Life course health development: An integrated framework for developing health, policy, and research. *Milbank Quarterly*, 80(3), 433-479. doi:10.1111/1468-0009.00019
- Harshaw-Ellis, K. (n.d.) *Integrated models of care: Bridging the hospital, the home and long term care*. Retrieved from http://nursing.duke.edu/wysiwyg/downloads/Harshaw-Ellis_PlenaryII_with_Lansiquot_101007.pdf.

- Hayward, M. D. (2002). Using the Health and Retirement Survey to investigate health disparities. Retrieved from <http://hrsonline.isr.umich.edu/sitedocs/dmc/KahnemanandLaibson.pdf>
- Hayward, M. D., Crimmins, E. M., Miles, T. P., & Yang, Y. (2000). The significance of socioeconomic status in explaining the racial gap in chronic health conditions. *American Sociological Review*, 65(6), 910-930. doi:10.2307/2657519
- Hoffmann, R. (2005). Do socioeconomic mortality differences decrease with rising age? *Demographic Research*, 13(2), 35-62. doi:10.4054/DemRes.2005.13.2
- Hollander, M. J., & Prince, M. J. (2002). *Analysis of interfaces along the continuum of Care. final report: The third way? A framework of organizing health related services for individuals with ongoing care needs and their families*. Retrieved from <http://www.hollanderanalytical.com/downloads/continuum-final.pdf>.
- Hollander, M. J., & Prince, M. J. (2008). Organizing healthcare delivery systems for persons with ongoing care needs and their families: A best practices framework, *Healthcare Quarterly*, 11(1), 44-54. Retrieved from <http://www.longwoods.com/publications/healthcare-quarterly>
- Hooyman, N. R., & Kiyak, H. A. (2008). *Social gerontology: A multidisciplinary Perspective*. Boston, MA: Allyn and Bacon.
- Husani, B.A. & Moore, S. T. (1990). Arthritis disability, depression, and life satisfaction among black elderly people. *Heath & Social Work*, 15(4): 253-260. Retrieved from <http://www.naswpress.org/publications/journals/hsw.html>
- Iwarsson, S. (2005). A long-term perspective on person-environment fit and ADL dependence among older Swedish adults. *The Gerontologist*, 45(3), 327-336. doi: 10.1093/geront/45.3.327
- Jagger, C., Matthews, R., Melzer, D., Matthews, F., Brayne, C. & MRC CFAS. (2007). Educational differences in the dynamics of disability incidence, recovery and mortality: findings from the MRC cognitive function and ageing study (MRC CFAS). *International Journal of Epidemiology*, 36(2), 358-365. doi:10.1093/ije/dyl307
- Jang, Y., Haley, W. E., Mortimer, J. A., & Small, B. J. (2003). Moderating effects of psychosocial attributes on the association between risk factors and disability in later life. *Ageing & Mental Health*, 7(3). 163-170. doi:10.1080/1360786031000101111

- Janke, M. C., Payne, L. L., & Van Puymbroeck, M. (2008). The role of informal and formal leisure activities in the disablement process. *International Journal of Aging & Human Development*, 67(3), 231-257. Retrieved from <http://www.baywood.com/journals/previewjournals.asp?id=0091-4150>
- Jette, A. M. (1996). Disability trends and transitions. In R. H. Binstock & L. K. George (Eds.), *Handbook of aging and the social sciences* (pp. 94-116). San Diego, CA: Academic Press.
- Jette, A. M., Hamilton, B. B., Liang, M. H., & Whiteneck, G. G. (1997). Disablement outcomes in geriatric rehabilitation. *Medical Care*, 35(6), 28-44. Retrieved from <http://journals.lww.com/lww-medicalcare/pages/default.aspx>
- Johnson, N. E. (2000). The racial crossover in comorbidity, disability, and mortality. *Demography*, 37(3), 267-283. doi:10.2307/2648041
- Johnson, R. W. (2007). *The burden of caring for frail parents*. Washington, D.C.: The Urban Institute.
- Kaiser Family Foundation. (2010). *Medicare chartbook (4th ed.)*. Washington DC: The Henry J. Kaiser Family Foundation. Retrieved from <http://www.kff.org/medicare/upload/8103.pdf>
- Katz, P. (2004). Function, disability, and psychological well-being. In M. R. Clark & G. J. Treisman (Eds.), *Pain and depression: An interdisciplinary patient-centered approach* (pp. 41-62). New York, NY: Karger Publisher.
- Katz, S., Ford, A. B., Moskowitz, R. W., Jackson, B. A., & Jaffe, M. W. (1963). Studies of illness in the aged. The Index of ADL: A standardized measure of biological and psychosocial function. *JAMA*, 185, 914-919. Retrieved from <http://jama.ama-assn.org/>
- Kaye, H. S., Yeager, P., & Reed, M. (2008). Disparities in usage of assistive technology among people with disabilities. *Assistive Technology*, 20(4), 194-203. doi:10.1080/10400435.2008.10131946
- Kaye, H. S., Kang, T., & LaPlante, M.P. (2000). Mobility device use in the United States. *Disability Statistics Report*, 14, 1-60. Retrieved from <http://dsc.ucsf.edu/main.php?name=publications>
- Kelley-Moore, J. A., & Ferraro, K. F. (2004). The Black/White disability gap: Persistent inequality in later life? *Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 59(1), S34-S43. doi:10.1093/geronb/59.1.S3
- Kemp, B. J. (1999). Quality of life while aging with a disability. *Assistive Technology*, 11(2), 158-163. doi:10.1080/10400435.1999.10131999

- Kemp, B. J., & Krause, J. S. (1999). Depression and life satisfaction among people ageing with post-polio and spinal cord injury. *Disability and Rehabilitation*, 21(5-6), 241-249. doi: 10.1080/096382899297666
- Kington, R. S., & Smith, J. P. (1997). Socioeconomic status and racial and ethnic differences in functional Status associated with chronic diseases. *American Journal of Public Health*, 87(5), 805-810. doi:10.2105/AJPH.87.5.805
- Kochera, A. (2002). *Accessibility and visitability features in single-family homes: A review of state and local activity*. Washington, D.C.: AARP Public Policy Institute.
- Korn, E. L., Graubard, B. I., & Midthune, D. (1997). Time-to-event analysis of longitudinal follow-up of a survey: Choice of the time-scale. *American Journal of epidemiology*, 145(1), 72-80. Retrieved from <http://aje.oxfordjournals.org/>
- Kodner, D. L. (2001). *Transforming care for the elderly through organizational innovation initiatives*. Retrieved from <http://www.mcgill.ca/files/healthchallenge/transforming.pdf>.
- Kodner, D. L. (2003). Consumer-directed services: Lessons and implications for integrated systems of care. *International Journal of Integrated Care*, 3(Apr-Jun), 1-7. Retrieved from <http://www.ijic.org/index.php/ijic>
- Kodner, D. L., & Kyriacou, C. K. (2000). Fully integrated care for frail elderly: Two American models. *International Journal of Integrated Care*, 1(Oct-Dec), 1-19. Retrieved from <http://www.ijic.org/index.php/ijic>
- Kondo, N., Kawachi, I., Hirai, H., Kondo, K., Subramanian, S. V., Hanibuchi, T., et al. (2009). Relative deprivation and incident functional disability among older Japanese women and men: prospective cohort study. *Journal of Epidemiology & Community Health*, 63(6), 461-467. doi:10.1136/jech.2008.078642
- Koster, A., Bosma, H., Kempen, G., Penninx, B., Beekman, A., Deeg, D., & van Eijk, J. (2006). Socioeconomic differences in incident depression in older adults: The role of psychosocial factors, physical health status, and behavioral factors. *Journal of Psychosomatic Research*, 61, 619-627. doi:10.1016/j.jpsychores.2006.05.009
- Kressin, N., & Petersen, L. (2001). Racial differences in the use of invasive cardiovascular procedures: Review of the literature and prescription for future research. *Annals Internal Medicine*, 135(5), 352-366. doi:10.2105/AJPH.94.12.2091
- Kressin, N. R., Raymond, K. L., & Manze, M. (2008). Perceptions of race/ethnicity-based discrimination: A review of measures and evaluation of their usefulness for the health care setting. *Journal of Health Care for the Poor and Underserved*, 19(3), 697-730. doi: 10.1353/hpu.0.0041

- Kuo, Y. F., Raji, M. A., Peek, M. K., & Goodwin, J. S. (2004). Health-related social disengagement in elderly diabetic patients: Association with subsequent disability and survival. *Diabetes Care*, 27(7), 1630-1637. doi:10.2337/diacare.27.7.1630
- Kutner, M.H., Nachtsheim, C. J., & Neter, J. (2004). *Applied linear regression models*, Boston, MA: McGraw-Hill Irwin.
- Lachance, M. E., & Seligman, J. S. (2009). *Involuntary retirement: Prevalence, causes, and impacts*. Paper presented at the Association for Public Policy Analysis and Management Annual Meeting, Washington, DC.
- Lamarca, R., Alonso, J., Gomez, G., & Munoz, A. (1998). Left-truncated data with age as time scale: an alternative for survival analysis in the elderly population. *Journal of Gerontology Series A: Biological Sciences and Medical Sciences*, 53A(5). M337-M343. doi:10.1093/gerona/53A.5.M337
- Lawton, M. P., & Brody, E. M. (1969). Assessment of older people: Self-maintaining and instrumental activities of daily living. *The Gerontologist*, 9(3), 179-186. doi:10.1093/geront/9.3_Part_1.179
- Lawton, M. P., & Nahemow, L. (1973). Ecology and the aging process. In C. Eisdorfer & M. P. Lawton (Eds.), *The Psychology of Adult Development and Aging* (pp. 619-674). Washington D.C.: American Psychological Association.
- Leclair, N., Leclair, S., & Brigham, C. R. (2009). The medical model of impairment. In S. Goldstein & J. A. Naglieri (Eds.), *Assessing Impairment: From theory to practice* (pp. 59-75). New York, NY: Springer. doi: 10.1007/978-1-387-87542-2_6
- Leutz, W. N. (1999). Five laws for integrating medical and social services: Lessons from the United States and the United Kingdom. *Milbank Quarterly*, 77(1), 77-109. doi:10.1111/1468-0009.00125
- Leutz, W. N., Capitman, J., Ruwe, M., Ching, V. N., Flaherty-Robb, M., McKenzie, M., et al. (2002). Caregiver education and support: Results of a multi-site pilot in an HMO. *Home Health Care Services Quarterly*, 21(2), 49-72. doi:10.1300/J027v21n02_04
- Liang, J., Xu, X., Bennett, J. M., Ye, W., & Quinones, A. R. (2009). Ethnicity and changing functional health in middle and late life: A person-centered approach. *Journal of Gerontology Series B: Psychological Sciences and Social Sciences*, 65B(4), 470-481. doi:10.1093/geronb/gbp114
- Lorig, K., Ritter, P. L., Stewart, A. L., Sobel, D. S., Brown, B. W., Bandura, A., et al. (2001). Chronic disease self-management program: 2-year health status and health care utilization outcomes. *Medical Care*, 39, 1217-1223. Retrieved from <http://journals.lww.com/lww-medicalcare/pages/default.aspx>

- Lund, R, Nilsson, C. J., & Avlund, K.(2010). Can the higher risk of disability onset among older people who live alone be alleviated by strong social relations? A longitudinal study of non-disabled men and women, *Age and Ageing*, 39(3), 319-326. doi:10.1093/ageing/afq020
- Lutz, B. J. & Bowers, B. J. (2007). Understanding how disability is defined and conceptualized in the literature. In A. E. Orto & P. W. Power (Eds.), *The psychological & social impact of illness and disability (5th ed.)* (pp. 11-21). New York, NY: Springer Publishing Company, LLC.
- MacAdam, M. (2008). *Frameworks of integrated care for the elderly: A systematic review*. Ontario, Canada: Canadian Policy Research Networks.
- Maddox, G. L., & Clark, D. O. (1992). Trajectories of functional impairment in later life. *Journal of Health and Social Behavior*, 33(2), 114-125. doi:10.2307/2137250
- Malhotra, R. (2001). The politics of the disability rights movements. *New Politics*, 8(3), 65-75. Retrieved from <http://newpol.org/>
- Manton, K. G., Gu, X., & Lamb, V. L. (2006). Change in chronic disability from 1982 to 2004/2005 as measured by long-term changes in function and health in the U.S. elderly population. *Proceedings of the National Academy of Sciences of the United States of America*, 103(48), 18374-18379. doi:10.1073/pnas.0608483103
- Manton, K. G., Poss, S., & Wing, S. (1979). The Black/White mortality crossover: Investigation from the perspective of the components of aging. *The Gerontologist* 19(3), 291-300. doi: 10.1093/geront/19.3.291
- Marge, M. (1988). Health promotion for people with disabilities: moving beyond rehabilitation. *American Journal of Health promotion*, 2, 29-44. Retrieved from <http://www.healthpromotionjournal.com/publications/journal.htm>
- Marshall, K., Urrutia-Rojas, X., Mas, S. F., & Coggin, C. (2005). Health status and access to health care of documented and undocumented immigrant Latino women. *Health Care for Women International*, 26(10), 916-936. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/16263663?dopt=Abstract>
- Matthews, R. J., Smith, L. K., Hancock, R. M., Jagger, C., & Spiers, N. A. (2005). Socioeconomic factors associated with the onset of disability in older age: A longitudinal study of people aged 75 years and over. *Social Science & Medicine*, 61(7), 1567-1575. doi:10.1016/j.socscimed.2005.02.007
- Menard, S. (2002). *Applied logistic regression analysis*, Thousand Oaks, CA: Sage Publications.

- Mendes de Leon, C. F., Gold, D. T., Glass, T. A., Kaplan, L., & George, L. K. (2001). Disability as a function of social networks and support in elderly African Americans and whites. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences* 56(4), S179-S190. doi: 10.1093/geronb/56.3.S179
- Mendes de Leon, C. F., Barnes, L. L., Bienias, J. L., Skarupski, K. A., & Evans, D. A. (2005). Racial disparities in disability: Recent evidence from self-reported and performance-based disability measures in a population-based study of older adults. *Journal of Gerontology Series B: Psychological Sciences and Social Sciences*, 60B(5), 8263-8271. doi: 10.1093/geronb/60.5.S263
- Mendes de Leon, C. F., Glass, T. A., & Berkman, L. F. (2003). Social engagement and disability in a community population of older adults: The new haven EPESE. *American Journal of Epidemiology*, 157(7): 633-642. doi: 10.1093/aje/kwg028
- Mendes de Leon, C. F., Seeman, T. E., Baker, D. I., Richardson, E. D., & Tinetti, M. E. (1996). Self-efficacy, physical decline, and change in functioning in community living elders: A prospective study. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences* 51(4), S183-S190. doi: 10.1093/geronb/51B.4.S183
- Merton, R. K. (1968). The Matthew effect in science. *Science*, 159, 56-63. doi:10.1126/science.159.3810.56
- Metlife Mature Market Institute. (2006). *The Metlife market survey of nursing home and home care costs*. Westport, CT: Metlife Mature Market Institute.
- Minaire, P. (1992). Disease, illness and health: Theoretical models of the disablement process. *Bulletin of the World Health Organization*, 70(3), 373-379. Retrieved from http://www.scielo.org/scielo.php?script=sci_serial&pid=0042-9686&lng=en&nrm=iso
- Minkler, M. (1990). Aging and disability: Behind and beyond the stereotypes. *Journal of Aging Studies*, 4(3), 245-260. doi:10.1016/0890-4065(90)90025-4
- Minkler, M., & Fadem, P. (2007). Successful aging: A disability perspective. In A. E. Orto, & P. W. Power (Eds.), *The psychological and social impact of illness and disability* (pp 568-581). New York, NY: Springer Publishing Company.
- Mittelman, M. (2002). Family caregiving for people with Alzheimer's disease: Results of the NYU spouse caregiver intervention study. *Generations*, 26(1). 104-106. Retrieved from <http://www.generationsjournal.org/generations/gen34-4/home.cfm>
- Mermin, G. B. T., Zedlewski, S. R., & Toohey, D. J. (2008). Diversity in retirement wealth accumulation. *Retirement Policy Program Brief*, 24. Washington, D.C.: The Urban Institute. Retrieved from <http://www.urban.org/publications/411805.html>

- Mishra, U. S., & Dilip, T. R. (2008, Nov. 29). Reflections on wealth quintile distribution and health outcomes. *Economic & Political Weekly*. Retrieved from <http://www.indiaenvironmentportal.org.in/files/Reflections.pdf>
- Moen, P., Erickson, M. A., & Dempster-McClain, D. (2000). Social role identities among older adults in a continuing care retirement community. *Research on Aging*, 22(5), 559-579. doi:10.1177/0164027500225005
- Moody-Ayers, S. Y., Mehta, K. M., Lindquist, K., Sands, L., & Covinsky, K. E. (2005). Black-white disparities in functional decline in older persons: The role of cognitive function. *Journal of Gerontology Series A: Biological Science and Medical Science*, 60(7), 933-939. doi: 10.1093/gerona/60.7.933
- Morris, J. (1998). *Pride against prejudice: Transforming attitudes to disability*. London, U.K.: Women's Press.
- Mukamel, D. B., Peterson, D. R., Temkin-Greener, H., Delavan, R., Gross, D., Kunitz, S. J., et al. (2007). Program characteristics and enrollees' outcomes in the Program of All-Inclusive Care for the Elderly (PACE). *Milbank Quarterly*, 85(3), 499-531. doi:10.1111/j.1468-0009.2007.00497.x
- Musa, D., Schulz, R., Harris, R., Silverman, M., & Thomas, S. B. (2009). Trust in the health care system and the use of preventive health services by older black and white adults. *American Journal of Public Health*, 99(7), 1293-1299. doi:10.2105/AJPH.2007.123927
- Mutchler, J. E., & Burr, J. A. (1991). Racial differences in health and health care service utilization in later life: the effect of socioeconomic status. *Journal of health and social Behavior*, 32, 342-356. doi:10.2307/2137102
- Nagi, S. Z. (1965). Some conceptual issues in disability and rehabilitation. In M. B. Sussman (Ed.), *Sociology and Rehabilitation* (pp. 100-113). Washington, D.C.: American Sociological Association.
- Nagi, S. Z. (1991). Disability concepts revisited: Implications for prevention. In A. M. Pope & A. R. Tarlov (Eds.), *Disability in America: Toward a national agenda for prevention* (pp. 307-327). Washington D.C.: National Academy Press.
- Nam, C. B., Weatherby, N. L., & Ockay, K. A. (1978). Causes of death which contribute to the mortality crossover effect. *Social Biology*, 25(4), 306-314. Retrieved from <http://www.soc.duke.edu/~socbio/>
- National Alliance for Caregiving and AARP. (2004). *Caregiving in the U.S.* Washington, D.C.: National Alliance for Caregiving. Retrieved from <http://www.caregiving.org/data/04finalreport.pdf>

- National Institute on Aging. (2007). *The Health & Retirement Study: Growing older in America*, NIH Publication No. 07-5757. Retrieved from <http://www.nia.nih.gov/researchinformation/extramuralprograms/behavioralandsocialresearch/hrsfull.htm>
- National Institute on Alcohol Abuse and Alcoholism. (2005). *Helping patients who drink too much. A clinician's guide*. Bethesda, MD: National Institute on Alcohol Abuse and Alcoholism. Retrieved from <http://pubs.niaaa.nih.gov/publications/practitioner/cliniciansguide2005/guide.pdf>
- National Registry of Evidence-Based Programs and Practices. (2008). *Program of All-Inclusive Care for the Elderly (PACE)*. Retrieved from http://www.nrepp.samhsa.gov/programfulldetails.asp?PROGRAM_ID=117
- National PACE Association (n.d.). *PACE approved as evidenced based model of care*. Retrieved from <http://www.npaonline.org/website/article.asp?id=4>.
- Nilsson, C. J., Lund, R., & Avlund, K. (2008). Cohabitation status and onset of disability among older Danes: Is social participation a possible mediator? *Journal of Aging and Health*, 20(2), 235–253. doi:10.1177/0898264307310474
- Noreau, L., Desrosiers, J., Robichaud, L., Fougereyrollas, P., Rochette, A., & Viscogliosi, C. (2004). Measuring social participation: Reliability of the LIFE-H in older adults with disabilities. *Disability & Rehabilitation*, 26(6), 346-352. doi:10.1080/09638280410001658649
- Oliver, M. (1983). *Social work with disabled people*. Macmillan, UK: Basingstoke.
- Oliver, M. (1996). Defining impairment and disability: Issues at stake. In G. Barnes & G. Mercer (Eds.), *Exploring the divide: Illness and disability* (pp. 39-54). Leeds, UK: The Disability Press.
- Ormel, J., Rijdsdijk, F. V., Sullivan, M., van Sonderen, E., & Kempen, G. I. (2002). Temporal and reciprocal relationship between IADL/ADL disability and depressive symptoms in late life. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 57(4), P338-347. doi: 10.1093/geronb/57.4.P338
- Ory, M., Hoffman, R. R., Yee, J. L., Tennstedt, S. L., & Schulz, R. (1999). Prevalence and impact of caregiving: A detailed comparison between dementia and nondementia caregivers. *The Gerontologist*, 39(2), 177-185. doi: 10.1093/geront/39.2.177
- Ozawa, M. N., & Yeo, Y. H. (2007). The effect of disability on the net worth of elderly people. *Journal of Aging and Social Policy*, 19(4), 21-38. doi:10.1300/J031v19n04_02

- Ozawa, M. N., & Yeo, Y. H. (2008). Race/ethnicity and socioeconomic class as correlates of disability in old age. *Journal of Gerontological Social Work*, 51(3/4), 337-365. doi:10.1080/01634370802039700
- Owen, G. M. (2008). Gender differences in health care expenditures, resource utilization, and quality of care. *Journal of Managed Care Pharmacy*, 14(3), S2-S6. Retrieved from <http://www.amcp.org/jmcphome.aspx>
- Pacala, J. T., Kane, R. L., Atherly, A. J., & Smith, M. A. (2000). Using structured implicit review to assess quality of care in the Program of All-Inclusive Care for the Elderly (PACE). *Journal of the American Geriatrics Society*, 48(8), 903-910. Retrieved from <http://www.wiley.com/bw/journal.asp?ref=0002-8614>
- Parentgiving. (2011). Common chronic conditions and aging at home: Chronic illness impacts some seniors' ability to live at home. Retrieved from <http://www.parentgiving.com/elder-care/common-chronic-conditions-and-aging-at-home/>
- Patridge, L., & Mangel, M. (1999). Messages from mortality: The evolution of death rates in the old. *Trends in Ecology and Evolution*, 14(11), 438-442. doi:10.1016/S0169-5347(99)01646-8
- Peek, M. K., Ottenbacher, K. J., Markides, K. S., & Ostir, G. V. (2003). Examining the disablement process among older Mexican American adults. *Social Science & Medicine*, 57(3), 413-425. doi:10.1016/S0277-9536(02)00367-2
- Pencina, M. J., Larson, M. G., & D'Agostino, R. B. (2007). Choice of time scale and its effect on significance of predictors in longitudinal studies. *Statistics in Medicine*, 26(6), 1343-1359. doi:10.1002/sim.2699
- Penninx, B. W., Leveille, S., Ferrucci, L., van Eijk, J. T., & Guralnik, J. M. (1999). Exploring the effect of depression on physical disability: Longitudinal evidence from the established populations for epidemiologic studies of the elderly. *American Journal of Public Health*, 89(9), 1346-1352. doi:10.2105/AJPH.89.9.1346
- Perenboom, R. J., & Chorus, A. M. (2003). Measuring participation according to the International Classification of Functioning, Disability and Health (ICF). *Disability and Rehabilitation*, 25(11-2), 577-587. doi:10.1080/0963828031000137081
- Peters, C. P. (2005). *Medicare Advantage SNPs: A new opportunity for integrated care?* Washington, D.C.: National Health Policy Forum.
- Petersen, L. A., Wright, S. M., Peterson, E. D., & Daley, J. (2002). Impact of race on cardiac care and outcomes in veterans with acute myocardial infarction. *Medical Care*, 40, 186-196. doi:10.1097/00005650-200201001-00010

- Pffeffier, D. (2001). Disability studies and the disability movement. In *Research in Social Science and Disability* (pp. 29-52). Stamford: JAI Press Inc.
- Phillips, J. R. (2002/2003). The RAND HRS data file: A user-friendly version of the Health and Retirement Study. *Social Security Bulletin*, 65(2), 97-98. Retrieved from <http://www.ssa.gov/policy/docs/ssb/>
- Polen, M. R., & Green, C. A. (2001). Caregiving, alcohol use and mental health symptoms among HMO members. *Journal of Community Health*, 26(4), 285-301. doi: 10.1023/A:1010308612153
- Popa, M. A., Reynolds, S. L., & Small, B. J. (2007). The role of health and lifestyle behaviors on White-Black disparities in disability. Retrieved from http://www.ined.fr/fichier/t_telechargement/14966/telechargement_fichier_en_709_popa_role.of.health.and.lifestyle.pdf
- Porell, F. W., & Miltiades, H. B. (2001). Disability outcomes of older Medicare HMO enrollees and fee-for-service Medicare beneficiaries. *Journal of the American Geriatrics Society*, 49(5), 615-631. doi:10.1046/j.1532-5415.2001.49123.x
- Putnam, M. (2002). Linking aging theory and disability models: Increasing the potential to explore aging with physical impairment. *The Gerontologist*, 42(6), 799-806. doi: 10.1093/geront/42.6.799
- RAND. (2005). *Future health and medical care spending of the elderly: Implications for Medicare*. Santa Monica, CA: RAND Corporation.
- RAND. (2010). *RAND HRS 2008 income and wealth Imputations*. Retrieved from <http://www.rand.org/content/dam/rand/www/external/labor/aging/dataproduct/fattable/doc/incwlth08e1a.pdf>
- Rao, J. N. K., & Scott, A. J. (1984). On chi-squared tests for multi-way contingency tables with cell proportions estimated from survey data. *Annals of Statistics*, 12, 46-60. Retrieved from <http://www.imstat.org/aos/>
- Reed, M. C., Hargraves, J. L., & Cassil, A. (2003). *Unequal access: African-American Medicare beneficiaries and the prescription drug gap*. Retrieved from <http://hschange.org/CONTENT/586/>
- Reynolds, S. L., & Silverstein, M. (2003). Observing the onset of disability in older adults. *Social Science & Medicine*, 57(10), 1875-1889. doi:10.1016/S0277-9536(03)00053-4
- Rodriguez, S.B., Diaz-Gimenez, J., Quadrini, V., & Rios-Rull, J. (2002). Updated facts on the U.S. distributions of earnings, income, and wealth. *Federal Reserve Bank of Minneapolis Quarterly Review*, 26(3), 2-35. Retrieved from <http://ideas.repec.org/s/fip/fedmqr.html>

- Rowe, J., & Kahn, R. (1987). Human aging: usual and successful. *Science*, 137, 143-149. doi:10.1126/science.3299702
- Rowe, J., & Kahn, R. (1997). Successful aging. *The Gerontologist*, 37(4), 433-440. doi: 10.1093/geront/37.4.433
- Rubin, R. M. (2002). The economic costs of informal elder caregiving. Retrieved from <http://www.entrepreneur.com/tradejournals/article/96810450.html>.
- Rubin, R. M., & White-Means, S. I. (2001). Race, disability and assistive devices: Sociodemographics or discrimination. *International Journal of Social Economics*, 28, 927-941. doi:10.1108/EUM00000000006133
- Sands, L. P., Wang, Y., McCabe, G. P., Jennings, K., Eng, C., & Covinsky, K. E. (2006). Rates of acute care admissions for frail older people living with met versus unmet activity of daily living needs. *Journal of the American Geriatrics Society*, 54(2), 339-344. doi:10.1111/j.1532-5415.2005.00590.x
- Satariano, W. (2005). *An epidemiology of aging: An ecological approach*. Sudbury, MA: Jones & Bartlett Publishing.
- Schmieding, L. (2006). *Caregiving in America: At home there's always Hope*. New York, NY: International Longevity Center.
- Schoeni, R. F., Martin, L. G., Andreski, P. M., & Freedman, V. A. (2005). Persistent and growing socioeconomic disparities in disability among the elderly: 1982-2002. *American Journal of Public Health*, 95(11), 2065-2070. doi:10.2105/AJPH.2004.048744
- Schulz, R., Beach, S. R., Ives, D. G., Martire, L. M., Ariyo, A. A., & Kop, W. J. (2000). Association between depression and mortality in older adults: The cardiovascular health Study. *Archives of Internal Medicine*, 160(12), 1761-1768. doi:10.1001/archinte.160.12.1761
- Shakespeare, T., & Watson, N. (1997). Defending the social model. In L. Barton & M. Oliver (Eds.), *Disability studies: Past, present and Future* (pp. 263-273). Leeds, UK: The Disability Press.
- Singer, J. D., & Willett, J. B. (2003). *Applied longitudinal data analysis: Modeling change and event occurrence*. New York, NY: Oxford University Press, Inc.
- Smart, J. F. (2007). The promise of the International Classification of Functioning, Disability, and Health (ICF). In A. E. Orto & P. W. Power (Eds.), *The psychological & social impact of illness and disability (5th ed.)* (pp. 582-595). New York, NY: Springer Publishing Company, LLC.

- Smedley, B. D., Stith, A. Y., & Nelson, A. R. (2003). *Unequal treatment: Confronting racial and ethnic disparities in health care*. Washington DC: The National Academies Press.
- Smith, S. R. (2009). Social Justice and disability: Competing interpretation of the medical and social models. In K. Kristiansen, S. Vehemas, & T. Shakespeare (Eds.), *Arguing about disability: Philosophical perspectives* (pp. 15-29). New York, NY: Routledge.
- Smith, S., Rayer, S., & Smith, E. (2008). Aging and disability: Implications for the housing industry and housing policy in the United States. *Journal of the American Planning Association*, 74(3), 289-306. doi:10.1001/archinte.160.12.1761
- Snowden L, R. (2003). Bias in mental health assessment and intervention: Theory and evidence. *American Journal of Public Health*, 93(2), 239–243. doi:10.2105/AJPH.93.2.239
- Song, J., Chang, H. J., Tirodkar, M., Chang, R. W., Manheim, L. M., & Dunlop, D. D. (2007). Racial/ethnic differences in activities of daily living disability in older adults with arthritis: A longitudinal study. *Arthritis and Rheumatism*, 57(6), 1058-1066. doi:10.1002/art.22906
- Stamm, T., & Machold, K. (2007). The International Classification of Functioning, Disability and Health in practice in rheumatological care and research. *Current Opinion in Rheumatology*, 19(2), 184-189. doi:10.1097/BOR.0b013e3280148e64
- StataCorp. (2009). *Stata survey data reference manual: Release 11*, College Station, TX: StataCorp LP.
- Stearns, S. C., Norton, E. C., & Yang, Z. (2007). How age and disability affect long-term care expenditures in the United States. *Social Policy and Society*, 6(3), 367-378. doi:10.1017/S1474746407003697
- Steinfeld, E., Levine, D. R., & Shea, S. M. (1998). Home modifications and the fair housing law. *Technology and Disability*, 8(1), 15-35. Retrieved from <http://www.deepdyve.com/browse/journals/technology-and-disability>
- Stone, R. I. (2000). *Long-term care for the disabled elderly: Current policy, emerging trends and implications for the 21st century*. Retrieved from <http://www.milbank.org/0008stone/>.
- Swain, J., French, S., & Cameron, C. (2003). *Controversial issues in a disabling society*. Buckingham, UK: Open University Press.
- Swain, J., Finkelstein, V., French, S., & Oliver, M. (1993). *Disabling barriers – Enabling environments*. London, UK: Sage Publications.

- Takeyachi, Y., Konno, S., Otani, K., Yamauchi, K., Takahashi, I., Suzukamo, Y., et al. (2003). Correlation of low back pain with functional status, general health perception, social participation, subjective happiness, and patient satisfaction. *Spine*, 28(13), 1461-1467. Retrieved from <http://journals.lww.com/spinejournal/pages/default.aspx>
- Taylor, C. (2005). Disabling barriers – Enabling environments. [Review of the book *Disabling barriers – Enabling environments* (2nd ed.), by J. Swain, S. French, C. Barnes, & C. Thomas]. *Health & Social Care in the Community*, 13(3), 283-284. Retrieved from <http://www.wiley.com/bw/journal.asp?ref=0966-0410>
- Taylor, M. G. (2008). Timing, accumulation, and the Black/White disability gap in later life - A test of weathering. *Research on Aging*, 30(2), 226-250. doi:10.1177/0164027507311838
- Taylor, M. G. (2010). Capturing transitions and trajectories: The role of socioeconomic status in later life disability, *Journal of Gerontology Series B: Psychological Sciences and Social Sciences*, 65B(6), 733-743. doi:10.1093/geronb/gbq018
- Taylor, M. G. (2011). The causal pathway from socioeconomic status to disability trajectories in later life: The importance of mediating mechanisms for onset and accumulation. *Research on Aging*, 33(1), 84-108. doi:10.1177/0164027510385011
- Terzi, L. (2004). The social model of disability: A philosophical critique. *Journal of Applied Philosophy*, 21(2), 141-157. doi:10.1111/j.0264-3758.2004.00269.x
- Thiebaut, A. C., & Benichou, J. (2004). Choice of time-scale in Cox's model analysis of epidemiologic cohort data: A simulation study. *Statistics in Medicine*, 23(24), 3803-3820. doi:10.1002/sim.2098
- Trupin, L., Rice, D. P., & Max, W. (1995). *Medical expenditures for people with disabilities in the United States, 1987*. Washington, D.C.: U.S. Government Printing Office.
- Tveteras, R., & Eide, G. (2000). Survival of new plants in different industry environments in Norwegian manufacturing: A semi - proportional Cox model approach, *Small Business Economics*, 14(1), 65 - 82. doi: 10.1023/A:1008189411442
- U. K. Union of the Physically Impaired Against Segregation. (1976). *Fundamental principles of disability*. London, UK: UPIAS and the Disability Alliance.
- U. S. Census Bureau. (2008). Americans with disabilities: 2005 household economic studies. Retrieved from <http://www.census.gov/hhes/www/disability/sipp/disable05.html>
- U. S. Census Bureau. (2010). *The next four decades: The older population in the United States 2010 to 2050 population estimates and projections*. Retrieved from <http://www.census.gov/prod/2010pubs/p25-1138.pdf>

- Van de Water, P. N., & Sherman, A. (2010). *Social Security keeps 20 million Americans out of poverty: A state by state analysis*. Washington D.C.: The Center on Budget and Policy Priorities.
- Van Ryn, M. (2002). Research on the provider contribution to race/ethnicity disparities in medical care. *Medical Care*, 40(1), 1140–1151. doi:10.1097/00005650-200201001-00015
- Van Ryn M, & Fu, S. S. (2003). Paved with good intentions: Do public health and human service providers contribute to racial/ethnic disparities in health? *American Journal of Public Health*, 93(2), 248–255. doi:10.2105/AJPH.93.2.248
- Verbrugge, L. M., & Jette, A. M. (1994). The disablement process. *Social Science & Medicine*, 38(1), 1-14. doi:10.1016/0277-9536(94)90294-1
- Victor, C. (2005). *The social context of ageing: A textbook of gerontology*. New York, NY: Routledge.
- Waidmann, T. & Freedman, V. (2006). The daily activities of the community-dwelling elderly: Evidence from the American time use survey. Retrieved from <http://aspe.hhs.gov/daltcp/reports/2006/cdelderly.htm>
- Waidmann, T. A., & Liu, K. (2000). Disability trends among elderly persons and implications for the future. *Journal of Gerontology Series B: Psychological Sciences & Social Sciences*, 55(5), S298-307. doi: 10.1093/geronb/55.5.S298
- Waite, L. J., & Hughes, M. E. (1999). At risk on the cusp of old age: Living arrangements and functional status among black, white and Hispanic adults. *Journal of Gerontology Series B: Psychological Sciences & Social Sciences*; 54, S136–S144. doi: 10.1093/geronb/54B.3.S136
- Wallace, R. B., Herzog, A. R., Ofstedal, M. B., & Fonda, S. J., Steffick, D., Langa, K. et al. (2004). Documentation of physical Functioning measured in the Health and Retirement Study and the asset and health dynamics among the oldest old study. Retrieved from <http://hrsonline.isr.umich.edu/sitedocs/userg/dr-008.pdf>
- Weiss, G. L., & Lonnquist, L. E. (1997). *The sociology of health, healing, and illness*. Upper Saddle River, NJ: Prentice Hall.
- Wing, S., Manton, K. G., Stallard, G., Hames, C. G., & Tryoler, H. A. (1985). The Black/White mortality crossover: Investigation in a community-based study. *Journal of Gerontology*, 40(1), 78-84. doi: 10.1093/geronj/40.1.78
- Winship, C., & Sobel, M. (2001). Causal inference in sociological studies. Retrieved from http://www.wjh.harvard.edu/~cwinship/cfa_papers/causalinference.pdf

- World Health Organization. (1980). *International classification of impairments, disabilities, and handicaps*. Geneva, Switzerland: World Health Organization.
- World Health Organization. (2001). *International classification of functioning*. Geneva, Switzerland: World Health Organization.
- World Health Organization. (2002). *Towards a common language for functioning, disability and health*. Retrieved from <http://www.who.int/classifications/icf/site/beginners/bg.pdf>.
- World Health Organization. (2008a). *International Classification of Impairments, Disabilities, and Handicaps*. Retrieved from <http://www.who.int/classifications/icf/en/>
- World Health Organization. (2008b). *Training manual on disability statistics*. Retrieved from <http://www.unescap.org/stat/disability/manual/Training-Manual-Disability-Statistics.pdf>
- Yaffe, K., Edwards, E. R., Covinsky, K. E., Lui, L. Y., & Eng, C. (2003). Depressive symptoms and risk of mortality in frail, community-living elderly persons. *American Journal of Geriatric Psychiatry*, 11(5), 561-567. doi:10.1176/appi.ajgp.11.5.561
- Young, T. K. (1998). *Population health: Concepts and methods*. New York, NY: Oxford University Press.
- Zsembik, B. A., Peek, M. K., & Peek, C. W. (2000). Race and ethnic variation in the disablement process. *Journal of Aging and Health*, 12(2), 229-249. doi:10.1177/089826430001200205